Federal Aviation Administration

Radio Spectrum Plan for 2001 – 2010

(2002 Revision)

Associate Administrator for
Air Traffic Services, ATS-1
September 30, 2002

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Executive Summary

The 2002 revision of the Radio Spectrum Plan for 2001-2010 provides an update on Very High Frequency (VHF) Air-Ground Communications, as well as a new Navigation section covering the broad range of navigation services. The VHF air-ground communications plan is responsive to a key recommendation of the next generation VHF air-ground communications system (NEXCOM) Aviation Rulemaking Committee (NARC), which recommended that the FAA should aggressively manage frequency assignments to prolong the useful life of the present 25 kHz system and conduct an annual assessment, looking ahead at least 5 years. The VHF air-ground communications and navigation services addressed in this report play a critical role in ensuring a safe and efficient air traffic control system in the United States. This spectrum plan is a support element in FAA's Capital Investment Plan (CIP) and Operational Evolution Plan (OEP).

It has become difficult to satisfy the increasing VHF air-ground voice communications system frequency assignment requirements. The purpose of the VHF air-ground communications section of this plan is to highlight the aggressive improvement measures that are being pursued by the FAA to help ensure that new air-ground safety communications (air traffic service (ATS) communications) requirements can be satisfied until 2010, when a new system is expected to be in operation.

FAA began a systematic study in late 2000 to identify what actions might be taken to extend the life of the present VHF communications system up to 2010. A broad study effort resulted in the identification of a total of 25 improvement measures, which are being pursued within the FAA and through coordination with concerned U.S. Government and non-Government agencies. The gains obtained from these improvement measures to date are highlighted herein.

Based on this study, it is concluded that the present VHF air-ground communications system will be able to support the efficient operation of the National Airspace System (NAS) until the 2010 time period, assuming that much of the estimated gain from the identified improvement measures can be achieved. Based on present information, it is estimated that approximately 1,500 new frequency assignment requirements will be needed to satisfy the air traffic control system needs until the year 2010. This estimate was based on a consideration of the long-term history of frequency assignment growth, a recent study of frequency assignments resulting from new requirements that surfaced over the past five years, and the implications of new initiatives that will require new frequency assignments. The spectrum resources available to satisfy the future requirements include the potential gain to be obtained from the 25 improvement measures and the significant spectrum resources available in many geographic areas (above and beyond that to be gained from the improvement measures), especially those outside of areas experiencing severe frequency congestion.

The purpose of the Navigation section of this plan is to ensure, to the maximum extent possible, that the future navigation system requirements to the year 2010 can be satisfied within the available radio spectrum. It is concluded that not all of the expected future requirements for the significant number of new Instrument Landing System (ILS) installations can be satisfied, in particular in high traffic density areas, due to severe frequency assignment congestion. Coordination will be initiated within the FAA to address this significant issue, including considering the possible alternatives to solve the problem and reaching a timely decision on the action to be taken.

A new worldwide frequency allocation was gained for the new Global Positioning System (GPS) L5 signal at the 2000 World Radiocommunication Conference. L5 will operate in the Distance Measuring Equipment (DME) band. In order to provide an interference free L5 signal, a plan will need to be established to re-frequency a number of DME channels. An issue still to be resolved with the Department of Defense is to obtain the needed power level for the new L5 civil signal, which, in the view of the FAA, is critical for the future success of GPS as a principal civil navigation system. No insurmountable problems are expected in satisfying the known frequency assignment requirements until 2010 for the other navigation systems addressed.

In the next year, the 25 VHF air-ground communications system improvement measures will be further developed and implemented. New requirements for both VHF and Navigation systems, as they surface, will continue to be addressed. In addition, a further expansion of this plan will be pursued to include other NAS system elements.

Steven J. Brown
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VHF Air-Ground Communications

1.1 Introduction

1.1.1 The three necessary functions required to provide a safe and efficient air traffic control service are communications, navigation, and surveillance (CNS). The air-ground safety communications element (air traffic service (ATS) communications) is provided for most overland areas through the use of very high frequency (VHF) spectrum resources within the 118-137 MHz band.

1.1.2 The 118-137 MHz frequency band, using double-sideband amplitude modulation (DSB-AM), has been used for many years to satisfy the ever increasing ATS air-ground voice communication requirements in the Continental United States (CONUS). (For clarification, it should be noted that ATS communications, i.e., safety communications, are sometimes informally called air traffic control (ATC) communications, even though the requirements extend beyond ATC usage.) However, while a new system, providing increased communications capacity and data link communications, has been pursued for nearly ten years, the burden still lies on the present VHF voice system to continue to satisfy most of the ever increasing requirements until the 2010 time period. The unexpected delay in implementing the new system has caused severe frequency assignment congestion to occur in some areas of the CONUS, requiring Airway Facilities to take drastic action to satisfy expected future requirements.

1.2 Purpose

1.2.1 The purpose of this plan is to provide an overview of the significant planning and action being taken by Airway Facilities (AF) to gain the additional air-ground communications capacity to satisfy new voice communications needs surfacing within the National Airspace System (NAS) until 2010. It is assumed that the next generation VHF air-ground communications system (NEXCOM) will be implemented and used to satisfy new requirements by 2010.

1.3 Background

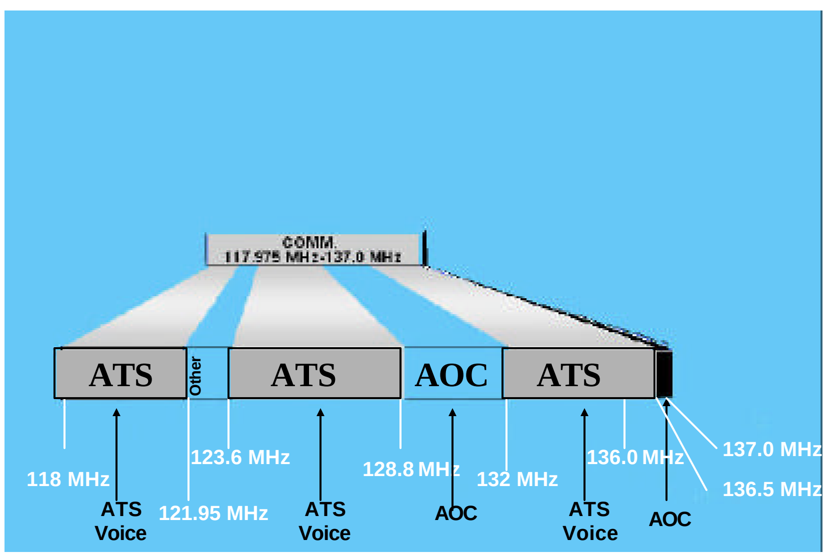
1.3.1 The use of the 118-137 MHz band for ATS communications has evolved over many years. The two broad categories of safety communications provided within the band are ATS and aeronautical operational control (AOC). AOC is provided and used by the airlines (and other users) for airline operational communications, flight following, etc. A more detailed background discussion on this and other aspects is presented in <u>Appendix 1.1</u>.

1.3.2 The channel capacity of the VHF band has increased significantly over the years through the implementation of channel splitting, the last, to 25 kHz, occurring in 1977. When the decision was made in the late 1970's to not implement satellite-based air-ground communications in the VHF band, the band segment 136-137 MHz was also added to the band (of which 136-136.5 MHz is available for ATS usage). However, the expansion of available channel capacity has been slow. While FAA issued an advisory circular in 1992 to voice the requirement for 25 kHz radios, there is still a strong general aviation desire in some areas to have non-25 kHz channel frequency assignments for certain operations.

1.3.3 Figure 1.1 provides a pictorial view of how the 118-137 MHz band is split up within the United States, showing that of the 760 (25 kHz) channels available in the band, only 524 are available for ATS. The remainder is used for AOC, general aviation, flight testing, etc. In addition, some of the 524 channels are used to coordinate fire fighting, support air shows, etc.

Figure 1.1
Limited VHF Resource to Meet Requirements

Total Channels Available = 760 ATS Channels = 524

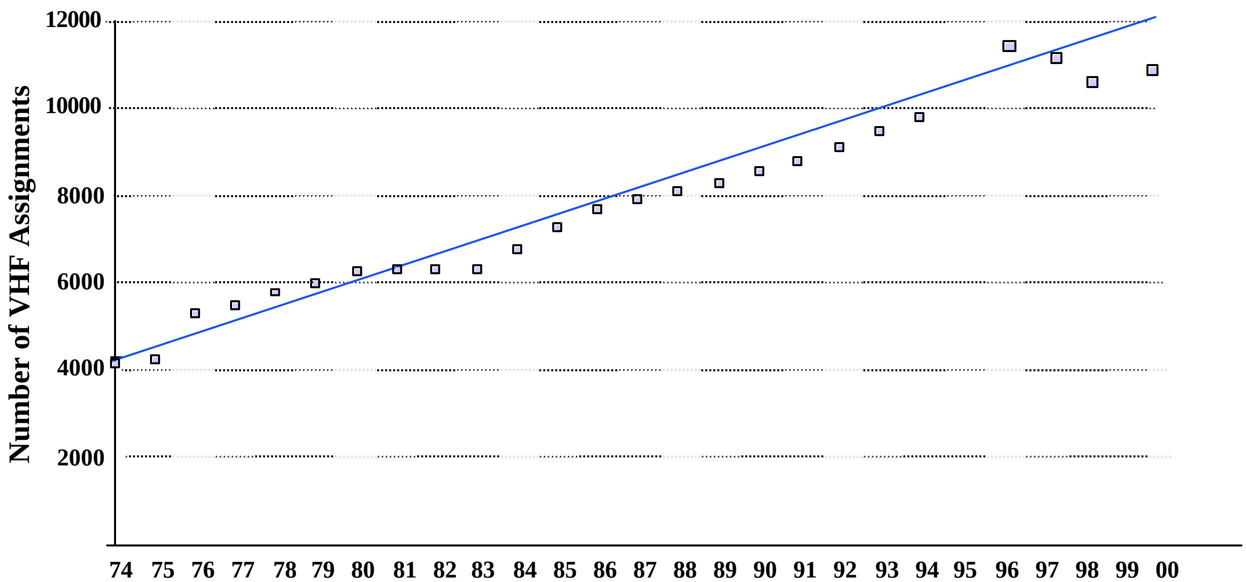


1.4 Future VHF ATS Air-Ground Frequency Requirements

1.4.1 The growth of VHF ATS frequency assignments, in response to ever-increasing requirements, has been quite linear over the past 25 years. Figure 1.2 shows that the average increase has been about 300 frequency assignments a year since the 1974 time frame.

Figure 1.2

Growth of ATS Frequency Assignments



Increase in number of channel assignments per year = 307 average

1.4.2 In order to more carefully examine the recent growth of frequency assignments, a new analysis was conducted which reviewed the growths of new frequency assignments (requiring a new protected service volume) over each of the past five years (from September 1997 through September 2002). In this analysis the total growth has been broken down into the three main categories: terminal, enroute, and broadcast. The results of this analysis are presented in Table 1.1. It should be noted that the average growth of approximately 120 frequency assignments per year is significantly lower than the growth of approximately 300 assignments per year shown in Figure 1.2. A number of factors help to explain this apparent discrepancy, as presented in Section 1.4.3 below.

Table 1.1

Five Year Growth of New VHF Air-Ground Frequency Requirements

	5-Year Growth	5-Year Growth %	Avg Growth / Year	Avg Growth / Year (%)
Total Terminal	151	3.73%	30.2	0.75%
Total Enroute	32	2.05%	6.4	0.41%
Total Broadcast	405	32.79%	81	6.56%
All Total:	**588**	**8.58%**	**117.6**	**1.72%**

1.4.3 First, as shown in Figure 1.2, the long term average growth of frequency assignments is subject to variations. In particular, a sizable number of frequency assignments were recovered in the latter 1990s as a result of frequency audits (the results of which are reflected in Figure 1.2). Another frequency audit conducted by Air Traffic (AT) resulted in the recovery of a significant number of frequency assignments during FY-2002 (see Improvement Measure 11 later in this report). Finally, as a result of the September 11, 2001, tragedy, and the resulting change of focus of the FAA and the airlines, very few new frequency assignments were made during the following year.

1.4.4 It must be recognized that it is not possible to exactly predict such characteristics as the number and service volumes (i.e., coverage requirements) of the new VHF air-ground ATS communication requirements that will surface up to the 2010 time period. However, taking into account the new air traffic control system changes (see Section 1.4.5), and the anticipated growth of air traffic in the future, it is expected that the future growth of frequency assignments will be significantly greater than that reflected by the past five year average.

1.4.5 This VHF plan is a support element in FAA's Capital Investment Plan (CIP) and Operational Evolution Plan (OEP), which address a number of new and pending air traffic control system changes that will require additional air-ground communications resources. The improvement areas include:

1) implementing "Choke Points" sectors ,

2) implementation of airspace redesign of the NAS…requiring the assignment of new sectors,

3) implementation of reduced vertical separation minimum (RVSM)…requiring frequencies to be assigned for the new sectors, and

4) the need for frequencies stemming from FAA AT requirements regarding the expansion of the non-movement areas at major airports.

1.5 Overview of Action Being Taken to Satisfy VHF Requirements to 2010

1.5.1 The focus of this plan is to satisfy VHF air-ground ATS voice requirements to the 2010 time period. While data link communications has been used for AOC for some years, it is presently being used for only non-time critical ATS communications. These data link services, as well as non-time critical controller to pilot data link communications, will continue to be provided from spectrum resources within the AOC allotment in the 118-137 MHz band by a service provider. ATS voice communication requirements continue to increase, in large part, because it is the air-ground communications element used for time-critical ATS communications.

1.5.2 Previous system improvements, which were concentrated on increasing efficiency, were quite effective over the time period that they were expected to be needed to help satisfy new requirements. However, with the initial operation of NEXCOM delayed to the 2010 time frame, additional measures are needed to help ensure that new communication requirements can be satisfied until that time period. These measures must be focused upon increasing the number of channels available for ATS communications. Thus, in late 2000, ASR began a systematic study to identify what actions might be taken to extend the life of the present system up to 2010. Unlike previous activities, this time significantly more aggressive actions needed to be considered. Included in these measures, for example, is the proposed use of 136-136.5 MHz, which had previously been identified for the initial implementation of NEXCOM. Such luxuries are no longer possible, since every possible spectrum resource must be marked for near term use.

1.5.3 As a result of a study performed within ASR and through coordination with the regional frequency management offices, 23 possible improvement measures were identified (later, two additional measures were identified, for a total of 25; hereafter these are referred to as the 25 improvement measures). Descriptions, expected benefits, and recommendations for each of these measures were developed. Subsequently, two face-to-face off-site meetings were held in February and April, 2001, with representatives from ASR, AF regional offices, AT, the William J. Hughes Technical Center, MITRE, and other concerned entities to address these possible measures in detail (see Acknowledgments page later in this section).

1.6 System Improvements Being Pursued and the Satisfaction of Requirements

1.6.1 The 25 improvement measures identified to be pursued involve a variety of technical, regulatory, and administrative changes. Many of these measures require coordination with other government agencies, in particular the Federal Communications Commission (FCC) and the National Telecommunications and Information

Administration (NTIA), and the user community (in particular, the general aviation community and the Aircraft Owners and Pilots Association, which represents this community). In addition, significant international coordination will be necessary to implement a number of the improvement measures. Coordination with Canada and Mexico will be needed, as well as coordination with the International Civil Aviation Organization (ICAO) and the International Telecommunication Union (ITU). Some of these measures require financial and technical resources to support such activities as system testing and computer software changes.

1.6.2 The candidate improvement measures would, if successfully implemented, result in a variety of spectrum management gains. A number would result in directly gaining new frequencies, some never before used for ATS, to be used to make new assignments. Others would result in improvements in the ability to make frequency assignments, through, for example, changes in the frequency assignment criteria.

1.6.3 It should be noted that there is no guarantee that all of these measures can be implemented, since they depend in large part on gaining agreement from other entities or on the results of testing. Many of these measures are quite costly and drastic in scope.

1.6.4 Further, the exact degree of improvement resulting from the totality of these measures cannot be precisely quantified. If additional improvement from the present system is needed in future years, beyond those to be gained with the identified actions, more drastic action might be pursued. However, such actions, such as separating the transmitter and receiver sites to improve co-site performance, would be coupled with significant costs to procure new land, build new facilities, etc.

1.6.5 Below, the 25 improvement measures being pursued are identified. These are identified as being short term, medium term, or long term, depending on whether they are anticipated to be implemented by the year 2003, 2005, or 2010, respectively. Table 1.2 provides a summary of the estimated improvement to be gained from each measure. A detailed plan for each of these measures has been developed and is being used by ASR to coordinate and track each measure. Appendix 1.2 contains additional information on these improvement measures, including the entities to be involved in the coordination and work to achieve the objective, an estimate of the schedule for completion of each measure, and a summary of the FY-2002 improvements gained from the measures (see Table A1.2-1). This appendix also provides an explanation of the assumptions used to estimate the improvement to be gained from these measures.

1) Investigate the use of part of the 121.5 MHz Guard Band for ATS assignments: Short Term

2) Seek alternative channels for the current two flight check frequencies: Medium Term

3) Investigate/review the current use of law enforcement channels and identify alternative frequencies for their use, e.g., UHF/Land Mobile: Short Term

4) Review the FCC frequency use plan, including investigating the use of UNICOM and other FCC aeronautical frequencies for ATS: Long Term

5) Investigate the possibility of using FSS channels for ATS, including the frequencies 123.6 MHz through 123.65 MHz: Medium Term

6) Investigate the use of the band segment 136-137 MHz for ATS: Medium Term

7) Review standard service volume guidelines in Order 6050.32: Short Term

8) Investigate the use of directional antennas for selected applications: Not being pursued (see Appendix 1.2)

9) Review and reassess policy of assigning AWOS and ASOS in sub-band: Short Term

10) Review assigning ground control in sub-band: Short Term

11) Conduct ATS Frequency Audit: Short Term

12) Investigate improved co-site mitigation techniques: Medium Term

13) Review air show frequency assignment policy: Short Term

14) Review fire-fighting frequency assignment policy: Short Term

15) Review use of VHF frequencies by the military and the use of the military common frequencies 126.2 MHz and 134.1 MHz: Medium Term

16) Investigate use of VOR frequencies for AWOS and ASOS broadcast function only: Medium Term

17) Investigate use of offset carrier operation for high altitude and ground service: Medium Term

18) Investigate the use of more select keying and voting systems, including reviewing the AT policy on simulcast transmissions: Short Term

19) Investigate lowering ground control transmitter antenna height and power output, if possible and practical, provided necessary coverage is maintained: Short Term

20) Investigate the advantages resulting from the optimization of the ground equipment geographical location with respect to the service volume: Short Term

21) Modify the AFM database to accept additional data and modify the frequency assignment model to work with these new data: Short Term

22) Improve coordination with ARINC and obtain a more accurate database from them: Short Term

23) Revise the air/ground model to accommodate a 0.6 nautical mile vertical separation: Short Term

24) Combine HIWAS and ASOS/AWOS service on VOR channels: Not being pursued (see Appendix 1.2)

25) Modify the air/ground model to give results by distance ratio instead of frequency order: Short Term

Table 1.2
Estimated Spectrum Use Improvement from the 25 Measures

Improvement Measure	Enroute: Gain - # of Assignments	Terminal: Gain - # of Assignments	Broadcast: Gain - # of Assignments	Gain: # of Assign. per Measure
1) 121.5 MHz Guard Band	0	0	488	488
2) Flight Check Frequencies	10	(78)*	(244)*	10
3) Law Enforcement Chs.	10	(78)*	(244)*	10
4) Review of FCC Use Plan	0	0	0	0
5) Use of FSS Chs.	90	(702)*	(2196)*	90
6) Use of 136-137 MHz. Segment	85	(663)*	(2074)*	85
7) Review std. Service volume	0	50	0	50
8) Use of directional antenna	0	0	0	0
9) Review AWOS & ASOS sub-band	0	100	0	100
10) Review gnd. Control sub-band	0	50	0	50
11) Conduct ATS freq. Audit	30	70	0	100

Table 1.2 Continued

Improvement Measure	Enroute: Gain- # of Assignments	Terminal: Gain- # of Assignments	Broadcast: Gain- # of Assignments	Gain: # of Assign. per Measure
12) Improve co-site mitigation	(30)+	(70)+	0	0
13) Review air show assign.	0	10	0	10
14) Review fire-fighting assign.	0	50	0	50
15) Review DOD use 126.2 & 134.1	5	12	0	17
16) VOR use for AWOS & ASOS	0	0	1342	1342
17) Use of offset carrier operation	15	15	0	30
18) Increase select key and voting sys.	50	50	0	100
19) Lower gnd. ctl. tx pwr./ant. height	0	10	0	10
20) Optimization of site location	10	0	0	10
21) Mod. AFM to accept add. Data	0	10	0	10
22) Improve coord. With ARINC	0	10	0	10
23) Accommodate 0.6 NMi vert. sep.	23	20	0	43
24) HIWAS/ASOS /AWOS on VOR	0	0	0	0
25) A/G model ch. for distance ratio	0	0	0	0
Total Gain: Num. of Assign/Use	328	457	1830	**Total Gain: __2615_Assign.**

Notes: * These numbers indicate that the improvement measure could also provide this many frequency assignments for the indicated function; however, the values are mutually exclusive. For example, a frequency assumed to be used to make enroute assignments could not then also be used for another function (i.e., terminal or broadcast).

+These numbers indicate that a decision to credit these benefits for this improvement measure has not been made, since the exact co-site improvement measures have not yet been decided. However, for this improvement measure, benefits are expected for both the enroute and terminal areas.

1.6.6 The analysis presented in Table 1.1 (which examined the growth of frequency requirements over the past five years) reflected a lower growth rate (1.72 percent) than the average growth rate shown in Figure 1.2 (approximately 3 percent in the early 1990s). As discussed in Sections 1.4.2 and 1.4.3, the lower growth rate over the past five years was not typical, and the growth rate is expected to increase (see Sections 1.4.4 and 1.4.5).

1.6.7 Thus, as a higher bound for growth, it is assumed that the future growth rate (for new frequency assignments requiring a new protected service volume) could return to the pervious 3 percent rate. This would result in a requirement for the next year of about 205 new frequency assignments (based on raising the average 1.72 percent rate of 117.6 assignments per year over the past five years to 3 percent). Extrapolating an assumed growth of 205 new frequency requirements per year until the 2010 time period, from the end of September 2002, would result in a requirement for approximately 1500 new frequency assignments (7.25 years x 205 frequency assignments per year). This growth rate will continue to be tracked each year to determine, apply, and take into account any correction that may be needed.

1.6.8 The resources available to satisfy the future requirements include the gain to be obtained from the 25 improvement measures, which could be as high as approximately 2,600 frequency assignments (see Table 1.2 above), assuming a fully successful implementation. The difficulty, however, of achieving these objectives must be recognized (see Section 1.6.3). There are still significant spectrum resources available for satisfying frequency assignment requirements in many geographic areas, especially those outside of areas experiencing severe frequency congestion.

1.6.9 Thus, based on study to date, it can be concluded that there will be sufficient spectrum resources available to allow the present VHF system to continue to support the efficient operation of the NAS until NEXCOM can be implemented in the 2010 time period, assuming that much of the estimated gain from the improvement measures can be achieved.

1.6.10 This plan will be updated yearly, with at least a five year outlook, to ensure the best possible view of future requirements and available spectrum resources to satisfy them. In the next year, the resulting frequency assignment requirements will be tracked, the improvement gains estimated to be derived from the 25 improvement measures will be refined, and the work will continue in pursuing the completion of the improvement measures.

1.6.11 This plan is responsive to the critical spectrum resource related Recommendation 1 of the NEXCOM Aviation Rulemaking Committee (NARC) report (Ref. 1.1), which recognizes the importance of having adequate VHF spectrum resources to make needed air-ground ATS frequency assignments.

1.7 Transition to the Future System - Basic Principles

1.7.1 As the year 2010 approaches, plans to implement the future VHF air-ground communication system, the four-circuit per 25 kHz time division multiple access (TDMA) voice and data link system (known as VDL Mode 3), will be completed. The early implementation of the future system, known as NEXCOM, will concentrate on voice communications. (It should be noted, however, that the future system is designed to provide voice and data link communications to an aircraft in a functionally simultaneous manner on the same 25 kHz channel, using a single antenna and radio.) The transition must be carried out in a phased approach, taking into consideration the equipage of the airspace users and the types of sectors to be implemented first. Prior to any operational implementation of NEXCOM, initial demonstration and validation testing must be completed.

1.7.2 It is anticipated that the commercial aircraft, and other aircraft that fly in the upper airspace, will be the first class of aircraft to be equipped with the future system. Clearly there will not be sufficient spectrum available to be able to provide access to both the present DSB-AM system and the VDL Mode 3 system even in the early operational implementation of the future system. Thus, all users in a sector implemented to operate on VDL Mode 3 must have a radio equipped to operate with this new system capability. However, the user's flight into an upper airspace sector implemented with the future system capability should be transparent to the pilot and controller (except for the new channel "numbering" included for the new system).

1.7.3 A more detailed discussion of the basic principles and issues of transition to the future system is provided in Appendix 1.3. This appendix also includes a brief discussion of the possibility of another option to that of NEXCOM, another channel split to 8.33 kHz for gaining additional VHF air-ground voice capacity, and the use of VDL Mode 2 for VHF air-ground data link. As recommended by the NARC, future planning is also being carried out on the development of an alternative transition plan to take into account the possibility of a transition in the NAS to 8.33 kHz channels. The results of this study will be reported in an upcoming revision of this plan.

1.8 Summary and Conclusions

1.8.1 It is becoming increasingly difficult in many areas of the NAS to find the spectrum resources necessary to make frequency assignments to support new VHF air-ground ATS communications requirements. In light of the expected delay to the 2010 time period for the initial operation of the NEXCOM, FAA has foreseen the need to take drastic action to obtain spectrum resources to support new VHF air-ground ATS communications requirements until then. AF, AT, and other concerned entities have identified and studied 25 improvement measures. These measures, most of which are seen as being drastic in scope, are being pursued toward implementation. The objectives of many of these measures can only be gained by obtaining the agreement of other Government and civil aviation entities, and coordination with neighboring countries and international organizations. Some of these measures require testing and validation.

1.8.2 The ultimate benefit of these improvements cannot be stated in an exact quantitative manner, since this depends in large part on the type (e.g., coverage requirements) and number of future frequency assignment needs to be satisfied. However, as highlighted in this report in Sections 1.6.7 and 1.6.8, these improvement measures, if successfully implemented and used in conjunction with present spectrum resources, are expected to be capable of supporting the efficient operation of the NAS until the 2010 time period. If needed, more drastic improvement measures could be taken, beyond those being pursued; however, such measures would require significant amounts of financial resources (e.g., to purchase land and construct buildings).

1.8.3 This plan will be updated yearly, with at least a five year outlook, so that any unforeseen changes in requirements and/or spectrum resources can be taken into account. This plan is a support element in FAA's CIP and OEP, and it is also responsive to Recommendation 1 of the NARC report, which highlights the critical nature of VHF spectrum resource availability and the need to examine such availability on a yearly basis.

Acknowledgments

(FY-2001 Initial Study)

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Background Discussion

1. 118-137 MHz Band usage

1.1 The use of the 118-137 MHz very high frequency (VHF) band for air-ground safety communications has evolved over many years. The band is allocated on a worldwide basis to the Aeronautical Mobile (Route) Service (AM(R)S) by the International Telecommunication Union (ITU). AM(R)S is a frequency allocation reserved to be used for safety and regularity of flight, that is safety communications. The two broad categories of communications provided within the AM(R)S are air traffic service (ATS) and aeronautical operational control (AOC). ATS broadly supports air traffic control, while AOC is provided and used by the airlines (and other users). AOC is used to satisfy federal air regulations requiring the airlines, in particular, to know where their aircraft are at all times (independently of air traffic control services), and the condition of their aircraft (fuel remaining, etc.).

2. Historical expansion of the capacity of the 118-137 MHz band

2.1 The capacity of the VHF band has increased significantly over the years through the implementation of channel splitting and incremental additions to the available spectrum resource. Each of these capacity improvements has required that users purchase new radios to receive the benefits of the additional channels. In 1966, a reduction in channel bandwidth from 100 kHz to 50 kHz doubled the number of channels available. The last channel split in 1977 from 50 kHz to 25 kHz again doubled the number of channels available in the band. In the late 1970's, the band segment 136-137 MHz was added to the VHF band as a result of a spectrum reallocation decision (resulting from a decision not to use VHF for satellite-based air-ground communications). However, as a result of a domestic allotment decision, only 136-136.5 MHz is available for ATS usage.

3. Impact of the long life of aircraft radios

3.1 Because of the long life of aircraft radios, it has taken many years, for general aviation in particular, to transition to the use of 25 kHz channels. With increasing pressures to gain additional channel capacity, FAA finally had to issue Advisory Circular 90-50D in 1992, stating the "Requirements for 760-Channel VHF Radio for Aeronautical Operations". However, there is still a strong general aviation desire in some areas to use 50 kHz or 100 kHz channel frequency assignments for certain operations.

4. Allocation of 118-137 MHz band within each country

4.1 Within the ITU, 118-137 MHz frequency allocation, each country has the flexibility to domestically allocate/allot the frequency band to specific services to satisfy the air-ground communication requirements within its boundaries. Thus, in the U.S. only 524 channels, of the total of 760 channels available in the band, are available for ATS. The remainder is used for AOC, general aviation, flight-testing, etc. In addition, some of the 524 channels available for ATS are used to coordinate fire fighting, by other federal agencies (Justice, the Department of Defense, etc.), for large air shows (10 assignments for Oshkosh and 5 for Lakeland), etc.

5. Consideration of frequency usage constraints

5.1 As expected, a single frequency can be used in more than one location in the CONUS. This is called frequency reuse. The degree of frequency reuse depends upon the altitude and service volume (i.e., the required coverage) of the specific service. For example, a frequency that is used for a high altitude sector might only be able to be reused three or four times in CONUS; this limited usage is required to ensure that there will be no radio frequency interference on the same frequency. Another factor is that of international borders. ASR must coordinate with Canada and Mexico to ensure that there is no interference between the frequencies being used; this factor can severely restrict the use of frequencies in CONUS.

6. Frequency assignment congestion and civil aviation community action

6.1 Frequency assignment congestion using the present 25 kHz channel spacing has been a concern for over a decade. This subject was addressed at length at the 1990 International Civil Aviation Organization (ICAO) Communications/Meteorology/ Operations Divisional Meeting (1990 COM/MET/OPS). Two high traffic density areas of the world (Western Europe and CONUS) were beginning to have difficulty in making new assignments by the 1990 time period. Western Europe pressed for another channel split to 12.5 kHz channel bandwidth. However, as a result of a United States proposal, a recommendation was adopted to carry out a broad system improvement study. Subsequently, the ICAO Aeronautical Mobile Communications Panel (AMCP) and the newly initiated RTCA, Incorporated, Special Committee (SC) 172 both conducted extensive studies on this subject.

6.2 The final report of SC-172, RTCA/DO-225, recommended that a new VHF air-ground voice and data link system be developed based upon a 4-circuit per 25 kHz time division multiple access (TDMA) design. This fully digital system would allow any mix of voice and/or data link circuits in any 25 kHz channel (e.g., 4 voice circuits). This design was also adopted at the subsequent 1995 ICAO Communications/Operations Divisional Meeting (1995 COM/OPS) as the future VHF air-ground communications system. However, the 1995 COM/OPS meeting also agreed upon standards and recommended practices (SARPs) for an 8.33 kHz bandwidth channel split that was to be implemented in the interim to increase voice channel capacity in Western Europe, which was then experiencing severe frequency assignment congestion. (The relative advantages/disadvantages of these systems have been addressed in other documentation. In addition, other activities, such as the NEXCOM Aviation Rulemaking Committee (NARC) have addressed the possible selection of which system to recommend for implementation in the NAS.)

7. System improvements implemented to combat frequency assignment congestion

7.1 In 1995, it was expected that the new system would be in operation by 2004. In order to continue to satisfy the new frequency requirements, a number of system improvements (i.e., improvements to the 25 kHz DSB-AM system) were pursued, including the following:

1) restrict the volume of service coverage,

2) use a relaxed 14 dB protection ratio for co-channel frequency assignments (coordinated through ICAO…the nominal ICAO protection ratio was 20 dB),

3) use of navigational aid voice outlets (VHF Omni Ranges and Non-Directional Beacons) for ATIS/AWOS/ASOS,

4) increased use of receiver multicouplers and transmitter combiners,

5) reduction of ground transmitted power, and

6) use of selective keying for large enroute sectors.

7.2 All of these improvements were implemented and have been very effective over the time period that that they were expected to be needed to help satisfy new requirements.

Discussion of the 25 Improvement Measures

1. Introduction

1.1 The purpose of this appendix is to present a brief discussion and information about each improvement measure identified in the body of this report. These measures have either been closed (i.e., dropped from further consideration), implemented, or are being pursued toward implementation. The objectives are to gain further improvements in terms of access to additional spectrum to make VHF ATS air-ground communications frequency assignments, or to obtain improvements in the use of the spectrum resources available to make these assignments. At the end of this appendix in Section 4, Table A1.2-1 presents a status summary of the 25 improvement measures to date.

2. Estimation of gain to be obtained from improvement measures

2.1 A related companion study (Ref. 1.2) was conducted by ASR to estimate the gain in frequency assignments to be obtained from the 25 improvement measures. The system assumptions used in this study are summarized as follows:

1) The continental U.S. was approximated by a rectangular figure 2,300 nautical miles (NM) wide by 1,200 NM high, and the resulting area was used to determine the number of assignments.

2) Alaska, Hawaii, and U.S. Possessions were left out of the study, since these areas are not subject to immediate frequency congestion problems. Therefore, an attempt was made to segregate the data from these areas. The combined frequency usage in these areas represents approximately 10 percent of the total number of assignments and 5 percent of the enroute frequency assignment usage.

3) Only the co-channel engineering criteria was factored into the calculations (it should be noted that co-site and adjacent channel considerations will somewhat reduce the actual number of possible assignments).

4) The assignments were to be made at the minimum distance that results in a 14 dB protection ratio.

5) The enroute service volume (i.e., coverage area) was defined as being 100 NM and 45,000 ft. This is a conservative assumption resulting in allowing co-channel assignments to be made using a 700 NM separation between stations. Using this separation, a total of five enroute assignments across the U.S. can be made per channel.

6) The approach control service volume (i.e., coverage area) was defined as being 60 NM and 25,000 ft. Co-channel assignments can be made using a 420 NM separation between stations. Using this separation, a total of 15 assignments can be made per channel. The local control service volume was defined as being 30 NM and 10,000 ft. Co-channel assignments can be made using a 210 NM separation between stations. Using this separation, a total of 62 assignments can be made per channel. In estimating the benefits to be gained for making terminal assignments, it is assumed that half of the channels are used for making approach control assignments, and the other half are used for making local control assignments.

7) The AWOS/ASOS service volume was defined as being 25 NM and 10,000 ft. Co-channel assignments can be made using a 150 NM separation between stations. Using this separation, a total of 122 assignments can be made per channel.

8) The frequency assignments estimated to be possible for the three categories (i.e., enroute, terminal, and broadcast services) are mutually exclusive. For example, a frequency assumed to be used to make enroute assignments could not then also be used for another function (i.e., terminal or broadcast).

3. Introduction and summary of the 25 improvement measures

3.1 In this section, the 25 improvement measures are introduced and summarized, including a brief description of the measure, the action being taken, the expected improvement to be gained, and the planned implementation schedule.

1) Investigate the use of part of the 121.5 MHz Guard Band for ATS assignments.

Summary of proposed action:

The emergency frequency, 121.5 MHz, has a 100 kHz guard band around it. In the more recent past, polar orbiting satellite receivers have been used to monitor for Emergency Locator Transmitter (ELT) transmissions. Both the United States and Russia have such satellite receiving systems, collectively known as COSPAS/SARSAT. This guard band has been protected to ensure that the noise floor of the satellite receivers would remain low. The objective of this improvement measure is to pursue the use of four of the six guard band channels around 121.5 MHz (121.425 MHz, 121.450 MHz, 121.550 MHz, and 121.575 MHz) to be used for low power, ground broadcast transmission functions only, with strict out-of-channel emission specifications. In practice, existing broadcast services would be moved to these channels, thus freeing up the other channels for general ATS use. New broadcast services would also be assigned to these channels. (See related Improvement Measure Number 9 below).

Coordination/Financial Support/Technical Support Necessary:

The FAA has coordinated tests with concerned United States agencies to demonstrate that there would be no interference to 121.5 MHz emergency signal alerting via the COSPAS/SARSAT satellite receivers and to FAA direction finding facilities from transmissions within the 121.5 MHz guard band. The testing involved regional Frequency Management Offices (FMOs), the FAA Technical Center, ASR, and other entities. In addition, the FAA needs to coordinate with ICAO to record an exception to the ICAO SARPs which keep frequencies vacant within the 100 kHz guard band around 121.5 MHz, and subsequently work to change the present ICAO standards in this area.

Expected Improvement (Additional Assignments, Assignment Flexibility, etc.):

Number of frequencies made available by initiative: 4

Possible broadcast assignments: 122 x 4 = 488
Note: This is the estimated maximum number of broadcast frequency assignments that could be made in the United States due to frequency assignment limitations. However, in order to ensure protection of COSPAS/SARSAT satellite receivers, the actual number of assignments might be less.

Implementation Schedule:

ASR study and conduct initial tests to determine the feasibility of using the four 121.5 MHz guard band channels for low power ATS broadcast services: Completed, March 2001

FAA analysis and associated tests show that there should be no interference to the satellite monitoring service, even with many broadcast transmission sites.

Conduct tests with the draft broadcast transmission criteria to determine the minimum distance broadcast transmission facilities can be from FAA Direction Finding receivers: Completed June 2001

It has been determined that the 121.5 MHz guard band broadcast sites should be kept at least 10 NM away from FAA direction finding sites, to protect the receivers at these sites.

Conduct tests with the draft broadcast transmission criteria to determine the potential for interference to Civil Air Patrol (CAP) onboard direction finders (DF): Completed, June 2001

It was determined that there would be no interference to CAP onboard DF's used in operational scenarios.

Complete the development of the broadcast transmission criteria: Completed, April 2001.

Coordinate with regions to re-assign at least six existing FAA ASOS/AWOS assignments and conduct validation tests to ensure that there will be no interference to the satellite receivers: December 2002

Assuming a satisfactory outcome of the testing at the six facilities, begin implementation of up to 100 operational broadcast frequency assignments on the four channels highlighted above, and monitor performance: December 2002

Assuming a satisfactory outcome of the implementation of the 100 assignments, implement a broader general usage of the four guard band channels for broadcast services: Begin January 2004

Coordinate with NTIA and the FCC to make needed regulatory changes to recognize the use of the selected 121.5 MHz guard band frequencies for selected ATS broadcast services, using stringent transmission criteria: TBD

Coordinate with ICAO to record a U.S. exception for the use of the selected 121.5 MHz guard band frequencies for ATS, and work to change ICAO standards to broadly allow such usage: TBD

2) Seek alternative channels for the current two flight check frequencies.

Summary of proposed action:

In this improvement measure, ASR is seeking to gain access to two alternate channels for use by FAA flight check, thus freeing up the two present flight check coordination frequencies (135.85 MHz or 135.95 MHz) for general ATS use. As a first measure, coordination with the Aerospace Flight Test Radio Coordinating Council (AFTRCC) is proposed to seek the use of 123.175 MHz for FAA flight check operations as the primary frequency. A footnote in the U.S. Radio Regulations allows 123.175 MHz to be used on a non-interference basis for flight check coordination purposes. In coordinating with the AFTRCC, ASR would also open up the subject of making other flight test frequencies below 136 MHz available for ATS, in exchange for like frequency resources above 136 MHz. It was learned during early preliminary investigation that the ground maintenance radios (used in coordinating with the airborne flight check aircraft) could not tune above 136 MHz. Therefore, action will be taken to obtain new maintenance radios, so that the alternative will exist to move the two flight check coordination frequencies above 136 MHz.

Coordination/Financial Support/Technical Support Necessary:

Coordination with the AFTRCC and Flight Standards would be needed to determine if a change in the flight check frequencies could be carried out. Coordination with Canada and Mexico should be undertaken to help ensure that there will be no interference to ATS in the NAS while using either of the flight check frequencies (Canada uses the same flight frequencies as the FAA).

Expected Improvement (Additional Assignments, Assignment Flexibility, etc.):

Number of frequencies made available by initiative: 2

Possible enroute assignments: 5 x 2 = 10
or
Possible terminal assignments: 39 x 2 = 78
or
Possible broadcast assignments:122 x 2= 244

Implementation Schedule:

Communicate with AFTRCC to coordinate the use of 123.175 MHz as a flight check coordination frequency: Completed, June 2001 (123.175 MHz to be used on a test basis for 6 months)

Issue letter to AVN-1 proposing that 123.175 MHz be used, for the next 6 months, as the first choice for flight check coordination, in order to evaluate the operational usability of this frequency: Completed, July 2001

ASR notify AFTRCC that 123.175 MHz will be used, for the next 6 months, as the first choice for flight check coordination, in order to evaluate the operational usability of this frequency: Completed, October 2001

Based on the test results obtained from AVN, which showed that there was interference from AFTRCC users that impacted the flight check missions, a letter was sent to AVN on 2/22/02 directing that the tests be stopped.

ASR coordinate with AVN to pursue a long-term flight check frequency coordination usage solution: Continuing

Coordinate with Canada and Mexico to ensure no interference in the use of a flight test frequency for flight inspection, assuming it is decided to use such a frequency for flight inspection: TBD

Coordinate with Canada and Mexico to ensure that there would be no interference in the ATS usage of flight check frequencies: TBD

Transition flight check communications into flight test frequency channels: TBD

Pursue the early availability of new maintenance radios capable of tuning above 136 MHz: Continuing

ASR-1 sent a memo to ARS-1 on June 28, 2002, stating a need for Airway Facilities to obtain 760 channel maintenance radios. Except for four aircraft (which will be equipped by mid-2003), all flight check aircraft are equipped to operate above 136 MHz.

3) Investigate/review the current use of law enforcement channels and identify alternative frequencies for their use, e.g., UHF/Land Mobile.

Summary of proposed action:

Both the Department of Justice and the Treasury Department have been assigned an ATS frequency nationwide to support law enforcement. The objective of this improvement measure is to seek phasing out operations on either or both of these frequencies, or at least move them temporarily above 136 MHz, so that the released channels below 136 MHz could be made available to satisfy ATS requirements.

Coordination/Financial Support/Technical Support Necessary:

Coordinate with the Departments of the Treasury and Justice to gain acceptance to free up two ATS frequencies below 136 MHz for ATS usage in the near term, by moving their usage above 136 MHz. In the longer term acceptance to a plan to move completely out of the ATS VHF band should be sought by the FAA.

Expected Improvement (Additional Assignments, Assignment Flexibility, etc.):

Number of frequencies made available by initiative: 2

Possible enroute assignments: 5 x 2 = 10
or
Possible terminal assignments: 39 x 2 = 78
or
Possible broadcast assignments:122 x 2 = 244

Implementation Schedule:

ASR communicate with the Treasury Department to seek a change in the ATS frequency they use for coordination: Completed, April 2001

A teleconference was conducted with the Treasury Department. It was learned that their frequency was used primarily for communications between their aircraft (no outside aircraft involved) and occasionally to communicate with Treasury Department personnel on the ground. The Treasury Department stated that they use their frequency mostly in Florida, South Texas, Arizona, and Southern California. The Treasury Department was willing to reduce their existing assignment to cover only the areas where the frequency was in use and allow the FAA to assign this frequency in at least the Northeast United States. The possibility of transferring to a VHF ATC frequency above 136 MHz was also discussed. The Treasury Department was willing to change frequencies. They agreed to review their aircraft equipage to determine if the transition could be made in the near future.

ASR communicate with the Department of Justice to seek a change in the ATS frequency they use for coordination: Completed, April 2001

It was expected that the Department of Justice requirements would be more complex. The Department of Justice has been working to transition to a single nationwide frequency from several regional frequencies (e.g., 135.8 MHz in Florida expires from the GMF on 1/31/2001). This single nationwide frequency would be used primarily to coordinate with local law enforcement aircraft that may not be equipped with radios capable of interfacing with other Department of Justice frequencies. Some other channel that would be available to the majority of the local law enforcement aircraft would probably be needed before the Department of Justice would agree to release the ATS frequency. It should be noted that there are several local/regional law enforcement groups that have been seeking dedicated frequencies in the 118-137 MHz band for their groups as well. One of the more vocal groups is based in California. It was noted that the Treasury Department frequency coverage should be transitioned to local coverage areas, instead of a nationwide coverage. It was also noted that the use of a UHF ATS frequency might be a possible alternative, since their aircraft are equipped with UHF AM radios.

Department of the Treasury submit a frequency change request to use a frequency above 136 MHz: Completed, July 2001

A Treasury frequency has been made available to satisfy an enroute assignment for the Geauga Sector (Cleveland Center): Commissioned, November 2001.

Department of Justice submit a frequency change request to use a frequency above 136 MHz: December 2002

Schedule a meeting with the Department of Justice to pursue the goal of establishing a plan to move out of ATS VHF band: October 2002

Schedule a meeting with the Department of the Treasury to pursue the goal of establishing a plan to move out of ATS VHF band: October 2002

Department of Justice transition out of 118-137 MHz band completed: TBD

Department of the Treasury transition out of 118-137 MHz band completed: TBD

4) Review the FCC use plan, including investigating the use of UNICOM and other FCC aeronautical frequencies for ATS.

Summary of proposed action:

The 66 channels in the frequency band 121.950 to 123.575 MHz (inclusive) are allocated for non-ATS functions. Currently 29 of these channels are allocated for Flight Service Station (FSS) functions and are managed by the FAA (FSS channel usage is addressed separately under Improvement Measure 5 below). The remaining 37 channels are assigned to other functions and are managed by the FCC. Of these 37 channels, 8 are UNICOM frequencies, 3 are MULTICOM, 2 are air-to-air coordination, 4 are aviation support, 2 are aeronautical enroute (non-ARINC), 17 are flight test, and 1 is international search and rescue. At present the 25 kHz UNICOM (122.725, 122.975, and 122.075), and some of the 17 flight test channels appear to represent the best targets for obtaining additional ATS frequencies. The number of flight test frequencies in a given area is limited by FCC rules to one per organization. Therefore, Boeing in Seattle should have only one flight test frequency. There are exceptions, and if facilities are located at different airports, multiple frequencies per organization are possible. Nevertheless, many of the flight test frequencies are probably largely unused in some sections of the U.S.

The objective of this improvement measure is to seek re-assignment of at least some of these frequencies for ATS usage. For example, a possible action might be to change the domestic air-to-air frequency of 122.750 MHz to the international air-to-air frequency of 123.400 MHz and then convert 122.750 MHz to an ATS function. In at least the longer term, the U.S. allocation of these frequencies would need to be changed to AM(R)S, to make the allocation consistent with ATS usage (i.e., for safety communications).

Coordination/Financial Support/Technical Support Necessary:

Coordination with the AFTRCC, the Aircraft Owners and Pilots Association (AOPA), and the FCC would be needed to discuss the possibilities of using these frequencies for ATS. In addition, coordination with the National Telecommunications and Information Organization (NTIA) and the FCC would be needed to pursue a domestic reallocation of these frequencies.

Expected Improvement (Additional Assignments, Assignment Flexibility, etc.):

TBD (Up to 20 (17 flight test and 3 UNICOM) frequencies may be made available for ATS usage.)

Implementation Schedule:

UNICOM:

Coordinate with AOPA to consider the possibility of using one or several UNICOM frequencies for ATS: Meetings held with AOPA in March and May 2001.

It was concluded that this measure would not be pursued, since there is increasing usage on the UNICOM channels.

Flight Test Frequencies:

Coordinate with AFTRCC to consider the usage of flight test frequencies for ATS: Completed June 2001.

A telecom was held with the AFTRCC in June. No definite decisions were made to use flight test frequencies for ATS. However, the AFTRCC was open to considering a swap to use a frequency above 136 MHz, in exchange for a flight test frequency below 136 MHz, which the FAA might use to establish a high altitude, enroute frequency assignment in the vicinity of Cleveland, Ohio.

Coordinate with the AFTRCC to determine if additional spectrum resources for ATS can be made available from industry test frequencies: Continuing TBD

An FAA letter was sent to AFTRCC on 12/5/2001 to request information on the use of flight test frequencies. Responses from AFTRCC included a spreadsheet on 3/11/02 and later data. A preliminary review of the data received to date indicates that an estimated cost of several million Dollars would be required to procure transceivers to allow a significant amount of AFTRCC operations to transition above 136 MHz. Additional review of data and coordination with AFTRCC will be carried out to identify possible cost beneficial alternatives to pursue further.

Coordinate with Canada and Mexico, when appropriate and necessary, to ensure that any future planned usage of flight test frequencies for ATS will not be subject to interference from cross border transmissions: TBD 2002

Coordinate with the NTIA, when appropriate and necessary, to consider the domestic reallocation of selected flight test frequencies to the AM(R)S: TBD

Coordinate with the FCC, when appropriate and necessary, to consider the domestic reallocation of selected flight test frequencies to the AM(R)S: TBD

5) Investigate the possibility of using FSS channels for ATS, including the frequencies 123.6 MHz through 123.65 MHz.

Summary of proposed action:

The 25 kHz frequencies in the FSS band, 121.975-122.675MHz (see FCC Part 87, Paragraph 87.173 "Frequencies", Subparagraph Y, Item (2)), are viewed as being under used or not used at all. In addition, 123.6-123.65 MHz (inclusive), identified as FSS Air Carrier Advisory Channels, are very much under used. The purpose of this improvement measure is to seek use of these channels for ATS.

The current GMF shows no assignments on the FSS frequencies 122.125, 122.175, 122.225, 122.275, 122.225, 122.375, 122.425, and 122.575 MHz, while the FSS frequencies 121.975, 122.025, 122.075, 122.475, 122.525, 122.625, and 122.675 MHz have 1 or 2 assignments in the GMF. In addition, the frequencies 122.425 MHz, 122.575 MHz, and 122.225 MHz were used for Fire Fighting in the year 2000 (west of the Mississippi). A review of the Airport/Facility Directory in early 2001 showed very few assignments on the three Air Carrier Advisory Channels (123.6-123.65 MHz inclusive). These frequencies were intended for use by FSS's to provide advisory services at airports where there was an FSS and no UNICOM. With the consolidation of the FSS's into AFSS's, this usage was no longer continued as a routine service. However, there are a few remaining uses of 123.6-123.65 MHz predominately at AFSS locations.

The Air Carrier Advisory Channels (123.6-123.65 MHz) are part of the ATS allocation in the FCC rules; they are considered as Aviation Assignment Group (AAG) frequencies in the NTIA manual; and they are listed as AM(R)S in the Table of Frequency Allocations in the NTIA Manual. It is considered that no regulatory changes will be needed to use these channels for ATS. However, with regard to the FSS band, severe constraints are contained in Footnote US31 and the U.S. frequency allocation table. The usage of the FSS band is limited to "private aircraft stations", and is not allocated to the AM(R)S.

Coordination/Financial Support/Technical Support Necessary:

Coordination with ATP-300 regarding the usage of the "Air Carrier Advisory Channels" is needed to transition the remaining usage on these channels to the FSS channels. For the longer term usage of the FSS channels for ATS, coordination will be needed with the NTIA and the FCC to seek the reallocation of the FSS channels to the AM(R)S.

Expected Improvement (Additional Assignments, Assignment Flexibility, etc.):

Number of frequencies made available by initiative: 18

Possible enroute assignments: 5 x 18 = 90
or
Possible terminal assignments: 39 x 18 = 702
or
Possible broadcast assignments:122 x 18 = 2196

Implementation Schedule:

Make the "Air Carrier Advisory Channels" (123.6-123.65 MHz) available for ATS: Completed, October 2001

Clear the remaining FSS channel assignments from three "Air Carrier Advisory Channels" (123.6-123.65 MHz) for ATS usage: July 2003

As of August 2002, there were 74 FSS frequency assignments on the three channels, 123.6-123.65 MHz, of which 16 were in Alaska. Some ATC orders concerning these channels remain to be changed (ATP-300 task).

Coordinate with AOPA to gain their support for the future use of several FSS channels for ATS usage: Completed, meetings held with AOPA March and May 2001

Based on discussions with AOPA, they indicated that they would have no problem with the FAA using FSS channels for ATS, provided that there would be no interference or degradation to present FSS services.

Coordinate with the NTIA to gain their support for an immediate wavier to use 122.275 MHz (and possibly other FSS frequencies) for ATS usage: Completed, May 2001

An FAA letter on this issue was sent to the NTIA on 4/19/01. As a result of further coordination, the NTIA sent a letter to the FCC on August 30, 2002, requesting a meeting to discuss this issue.

Coordinate with the FCC, with the support of the NTIA, and gain an immediate waiver from the FCC to use 122.275 MHz (and possibly other FSS frequencies) for ATS usage: October 2002

Coordinate with the FCC and the NTIA, to effect the needed regulatory changes, as deemed necessary, to effect a permanent future basis for use of FSS channels for ATS usage: TBD

6) Investigate the use of the band segment 136-137 MHz for ATS.

Summary of proposed action:

Presently, a part of the 136-137 MHz band segment (136-136.5 MHz) could be used for ATS (three of the 20 available frequencies have been assigned to digital flight information service (FIS) usage on a temporary 5 year basis, which has been extended to 2007. This band segment has not been used, because in the past not very many users were equipped with radios that were able to tune to this band. (Attempts were made to make a frequency assignment from this band segment starting in July 2001, (e.g., Geauga Sector, Cleveland Center and approach control in St. Louis) but not enough aircraft were equipped to allow such usage. However, by 2003, this band might be usable for high altitude enroute sectors.) The objective of this improvement measure is to seek the use of this new spectrum resource for ATS voice communications. In addition, ASR will seek to move other services, such as flight test, law enforcement, and flight inspection communications, to 136-136.5 MHz (largely on a temporary basis) in exchange for the use of frequencies below 136 MHz for ATS usage (See related Improvement Measures 2 and 3). ASR would seek to use new spectrum resources resulting from this improvement to satisfy the requirements of such critical areas as "choke points".

Coordination/Financial Support/Technical Support Necessary:

Coordination with both AT and the users that routinely fly in the upper airspace (in particular commercial and business aviation, and the Department of Defense) will be required to seek agreements on the usage of channels above 136 MHz in selected sectors.

Expected Improvement (Additional Assignments, Assignment Flexibility, etc.):

Number of frequencies made available by initiative: 17

Possible enroute assignments: 5 x 17 = 85
or
Possible terminal assignments: 39 x 17 = 663
or
Possible broadcast assignments:122 x 17 = 2074

Implementation Schedule:

Coordinate within FAA to seek opportunities of geographic locations and airspace applications (e.g., high altitude) for using channels above 136 MHz for ATS: Continuing

Coordinate with selected segments of the user community to pursue the use of channels above 136 MHz for ATS: Continuing

The goal is to begin usage of the band above 136 MHz for ATS in 2003. It is too early as of this update to objectively state the exact date and number of frequency assignments to be obtained from this improvement.

7) Review standard service volume guidelines in Order 6050.32.

Summary of proposed action:

The purpose of this improvement measure is to press for changes in the standard service volume (i.e., coverage) following a review of the results of the AT frequency audit. Currently, there are several standard service volumes depicted in Appendix 2 of FAA Order 6050.32A. If the size of service volumes could be decreased, an increase in spectrum use efficiency could result. For example, many service volumes for approach control use 60 miles as the radius around the airport and a maximum altitude of 25,000 feet. However, the radar coverage is typically 50 miles, and the hand-off from center to terminal normally takes place at or below 19,000 feet. Thus, the service volumes can be wasteful in both horizontal area and altitude. AT is aware of this improvement measure, and will ensure that the frequency audit data includes information to allow the service volume needs to be considered for the frequency assignments.

Coordination/Financial Support/Technical Support Necessary:

Coordination between AT and the FMOs will be needed to ensure that a productive examination of the service volumes can be carried out.

Expected Improvement (Additional Assignments, Assignment Flexibility, etc.):

Number of frequency assignments estimated to be made available by initiative: 50 Terminal

Implementation Schedule:

ASR communicate to FMO's and AT the decision to specify coverage areas based on actual requirements rather than a fixed service volume for specific services: Completed October 2001

ASR amend 6050.32 to specify coverage areas based on actual requirements rather than a fixed service volume for specific services: June 2003

8) Investigate the use of directional antennas for selected applications.

Summary of proposed action:

The objective of this improvement measure is to pursue the possibility of using directional antennas as a possible means of improving spectrum use efficiency. Certain frequency applications may allow the use of directional antennas, since the communications with pilots may be isolated to certain directions.

After investigation, including a meeting with representatives from AT, it was concluded that it would not be cost beneficial to pursue this improvement measure further. Considerations taken into account in making this decision, were the following: (a) directional antennas are already in use in some applications, and (b) there wouldn't be much of an improvement in spectrum use efficiency even if the remaining uses for directional antennas were implemented.

9) Review and reassess policy of assigning AWOS and ASOS in sub-band.

Summary of proposed action:

In order to improve the use of the 118-137 MHz band, the number of frequencies reserved for specific uses needs to be minimized. This measure is aimed at eliminating the sub-band reserved for broadcast services (including Automated Terminal Information Systems (ATIS), Automated Weather Observing Systems (AWOS), and Automated Surface Observing Systems (ASOS)).

It has also been proposed that the four previously unused emergency guard band frequencies (121.425 MHz, 121.450 MHz, 121.550 MHz, and 121.575 MHz), as well as 120.000 MHz, will be the only frequencies reserved solely for broadcast services. (Transmissions on 120.000 MHz from many aircraft carrying onboard computer systems or other high frequency "clocks" have resulted in interference due to the mixing of the VHF transmissions and signals emanating from these onboard devices; therefore, 120.000 MHz has been reserved for broadcast transmission services.) Further, these frequencies should be preferred as the first choice for all new AWOS/ASOS assignments. In the future, it is planned to also approve the use of these frequencies for ATIS assignments. Additional benefits, beyond those identified below, will be possible if present broadcast frequency assignments can be moved to the unused emergency guard band.

Coordination/Financial Support/Technical Support Necessary:

Assistance from the FMOs is needed to draft new guidelines covering the conditions for moving present broadcast assignments and making new broadcast assignments.

Expected Improvement (Additional Assignments, Assignment Flexibility, etc.):

Number of frequency assignments estimated to be made available by initiative: 100 Terminal

Implementation Schedule:

Develop a draft of the new guidelines, which significantly modifies the selection criteria for making frequency assignments for broadcast services: Completed, July 2001

Review, coordinate, and implement the new guidelines: Completed, August 2001

A letter was sent to the AF division managers communicating the new guidelines. The new guidelines are being used by ASR.

Change AFM to include a means of selecting new broadcast frequency assignments consistent with the new guidelines: Completed, June 2001

Update AWOS Advisory Circular (Number 150/5220-16C dated 12/13/99) to reflect new guidelines: TBD

Update Order 6050.32 to reflect new guidelines: June 2003

10) Review assigning ground control in sub-band.

Summary of proposed action:

In order to improve the use of the 118-137 MHz band, the number of frequencies reserved for specific uses needs to be minimized. This measure is aimed at eliminating the sub-band reserved for ground control communications frequency assignments. Subsequent to this change, new ground control frequency assignments will be selected from the broader band segments of frequencies available for ATS.

Coordination/Financial Support/Technical Support Necessary:

Coordination with the FCC and the NTIA is needed to update Part 87 and the NTIA Manual, respectively, to reflect the broader frequency band to be allowed in the selection of ground control frequency assignments. Coordination is needed with Canada and Mexico to ensure that this new flexibility is reflected in the cross-border frequency coordination guidance; coordination in a similar manner may be needed with Mexico.

Expected Improvement (Additional Assignments, Assignment Flexibility, etc.):

Number of frequency assignments estimated to be made available by initiative: 50 Terminal

Implementation Schedule:

Update AFM to eliminate present sub-bands in making ground control frequency assignments: Completed, May 2001

Coordinate with FCC and complete update of Part 87: December 2002

Update Order 6050.32 to reflect this new policy: June 2003

Update Advisory Circular 90-50 to reflect this new policy: December 2002

Coordinate with Canada and Mexico regarding the elimination of the use of sub-bands in making ground control frequency assignments: TBD

File an exception with ICAO regarding the elimination of the use of sub-bands in making ground control frequency assignments: December 2002

11) Conduct ATS Frequency Audit.

Summary of proposed action:

The objective of this improvement measure is to gain spectrum resources resulting from the identification of unused, underused, or misused frequency assignments. To accomplish this objective, ASR is coordinating with AT, which is conducting a broad frequency assignment audit within the NAS. A sizable gain in spectrum resources is expected, which would be used to satisfy new requirements (the goal established was to recover one percent of the assignments).

Coordination/Financial Support/Technical Support Necessary:

Coordination with AT and with regional Frequency Management Offices is needed to accomplish this objective.

Expected Improvement (Additional Assignments, Assignment Flexibility, etc.):

Number of frequencies made available by initiative: 100 assignments

Possible enroute assignments: .30 x 100 = 30
or
Possible terminal assignments: .70 x 100 = 70

Implementation Schedule:

AT complete the frequency assignment audit and communicate results to ASR and FMO's: Completed, August 2001

ASR receive from AT the validated list of frequencies to be recovered: Completed, October 2001

An ATP-1 memo dated 10/16/01 states that 43 VHF and 27 UHF frequency assignments have been recovered.

ASR notify the FMO's of the frequencies to be recovered: Completed, November 2001

Complete the update of the GMF using the results of the Audit to show the frequencies recovered: December 2002

Complete the comparison of the GMF with the results of the Audit, showing discrepancies, and update the GMF accordingly: December 2003

12) Investigate improved co-site mitigation techniques.

Summary of proposed action:

The objective of this improvement measure is to investigate, and implement as appropriate, possible data base information and technical improvements to mitigate the potential for co-site interference at ground receiver and transmitter sites. The candidate improvements included the use of, or increased use of, as appropriate: a) filters, multicouplers, and combiners; b) separate sites for transmitters and receivers; c) stacked antennas; d) use other existing sites to separate receiver(s) and transmitter(s); e) reduce power for terminal services; f) eliminate power amplifiers; g) redefine intermodulation criteria by taking into consideration transmitter power and receiver sensitivity; and h) raising the receiver squelch threshold. Companion analysis would be conducted to consider the potential spectrum use efficiency improvement to be gained by implementing these measures to improve the co-site environment.

Coordination/Financial Support/Technical Support Necessary:

Close coordination among ASR, the FMO's, and AND would be necessary to evaluate and implement a combination of these measures.

Expected Improvement (Additional Assignments, Assignment Flexibility, etc.):

Number of frequency assignments estimated to be made available by initiative: 100 (30 Enroute, 70 Terminal)

Note: The benefits of this improvement measure have not been credited in this VHF Frequency Management Plan, since the exact co-site improvement measures have not yet been decided.

Implementation Schedule:

ASR and FMO's review ANM memorandum proposing funding planning for radio frequency interference (RFI) elimination, and provide comments to ANM-473FN: Completed May 2001

Coordinate development of 2002 spending plan with AND to ensure FMO's get funding for RFI mitigation: Completed, August 2001

Develop regional RFI mitigation requirements at Baltimore FMO Seminar: Completed, June 2001

ANM provide a course on filtering for FMO's: Completed July 2001. Courses are being conducted at ANM.

William J. Hughes Technical Center (ACB) conduct flight tests to determine if terminal service transmitter power can be reduced, and report on any possible reduction: Completed, July 2001.

ANM review the intermodulation model, and consider refining the criteria, without requiring any mandatory inputs: Completed, August 2001

ACB develop criteria on transceiver/receiver co-site mitigation for manual use on case-by-case basis: Continuing

Decide which co-site improvements will be implemented: TBD

Modify the AFM as required: TBD

13) Review air show frequency assignment policy.

Summary of proposed action:

The objective of this improvement measure is to investigate the FAA's air show frequency assignment policy to see if any channels could be released for operational use. In early 2001 there were 82 pending records for frequency assignments used for air shows that were reserved in the Automated Frequency Manager (AFM). There were an additional 15 records reserved in the Government Master File (GMF) for large air shows, such as Lakeland and Oshkosh. It should be noted that these frequencies are used in the NAS to satisfy ATS requirements in other areas as possible. It might be possible to designate "start" and "stop" dates for air show frequency assignments, thereby allowing the same frequency to be reused at different air shows.

Coordination/Financial Support/Technical Support Necessary:

Coordination between ASR and the FMO's will be necessary to develop a means to reduce the number of air show frequency assignments, with a view of freeing up channels for ATS use. In addition, coordination with AT will be necessary to ensure that safety is maintained at the air shows.

Expected Improvement (Additional Assignments, Assignment Flexibility, etc.):

Number of frequency assignments estimated to be made available by initiative: 10 Terminal

Implementation Schedule:

AGL develop draft guidelines to more spectrum efficiently support air shows, coordinate with all regions, and forward consensus to ASR: October 2002

ASR distribute final policy: December 2002

Prepare an AFM software change request and submit to contractor: Completed, August 2001

Complete the modification of the AFM to include the new "start" and "stop" dates for air show frequency assignments: Completed, September 2001

14) Review fire-fighting frequency assignment policy.

Summary of proposed action:

ATS frequencies are used for coordination in support of aerial water drops on wildfires in areas inaccessible to ground based fire-fighting equipment. These operations are primarily located in the Western United States; however, operations in the Shenandoah National Park in Virginia and swamp areas in Florida are not unusual. The coordination of seasonal fire-fighting frequencies was traditionally accomplished on a local level through the FAA Regional Frequency Management Offices. In recent years, much of the local coordination has been assumed by the National Interagency Fire Center (NIFC) in Boise, ID. In an effort to reduce the numbers of frequencies reserved for fire-fighting, much of the regional coordination (especially east of the Mississippi) has been through ASR. However, in some cases as many as 6 frequencies have been assigned to a single area. In the year 2000, there were as many as 349 assignments in the pending file to support fire-fighting operations.

As a result of a December 2000 meeting with the NIFC, some changes to the frequency assignment policy were made. These changes included a reduction in the number of frequencies assigned to fire-fighting areas to a single frequency, with the NIFC coordinating additional frequencies as needed. In addition, the Fire-Fighting Contingency plan was reviewed and reissued before the start of the fire season in April. This plan included a revised list of area frequencies and a current list of after hours contacts. The NIFC also agreed to investigate the possibility of using frequencies in 136-136.5 MHz or in the 162-174 MHz band for fire-fighting coordination purposes.

Coordination/Financial Support/Technical Support Necessary:

Close coordination will be needed between ASR and the FMO's, and with the NIFC to ensure that minimum number of ATS frequencies will be needed for fire-fighting coordination. In particular, it may be possible to free some frequencies for ATS usage. Coordination with the FCC will also be needed to consider the possibility of using flight test frequencies for fire-fighting coordination.

Expected Improvement (Additional Assignments, Assignment Flexibility, etc.):

Number of frequency assignments estimated to be made available by initiative: 50 Terminal

Implementation Schedule:

AWP prepare a national fire-fighting plan, coordinate it with FMO's, and forward resultant draft to ASR: Completed, June 2001

All regional FMO's clean up databases relating to fire-fighting coordination requirements: Completed, September 2001

ASR meet with AFTRCC to consider the use of flight test frequencies for fire-fighting coordination: Completed, February 2002

AFTRCC has no problem supporting fire fighting provided that prior coordination has been completed.

Meet with NIFC and AFTRCC to coordinate use of AFTRCC frequencies for operational fight fighting: TBD

ASR and selected regional representatives meet with NIFC to discuss the long-range plan for frequency use, with a view of getting fire fighting coordination out of the ATS VHF band, or, as a temporary measure, establish use above 136 MHz: TBD

15) Review use of VHF frequencies by the military and the use of the military common frequencies 126.2 MHz and 134.1 MHz.

Summary of proposed action:

The objective of this improvement measure is to gain release of the frequencies 126.2 MHz and 134.1 MHz (and other VHF air-ground frequency assignments) from the DOD; these frequencies would be used to satisfy ATS air-ground communications requirements. This initiative was taken because it is believed that these frequencies and other frequency assignments are not being used for ATS communication purposes. The DOD has other VHF air-ground frequency assignments to satisfy ATS functions. There are about 45 DOD related frequency assignments on these two frequencies nationwide. In addition, the FAA will pursue the recovery of other VHF air-ground frequency assignments from DOD.

Coordination/Financial Support/Technical Support Necessary:

Coordination with the Executive Secretary, DOD Policy Board on Federal Aviation (PBFA) is necessary to both surface this proposed action and gain an agreement to get back these frequencies for general ATS usage.

Expected Improvement (Additional Assignments, Assignment Flexibility, etc.):

Number of frequencies made available by initiative: 1
Possible enroute assignments: 5 x 1 = 5

Number of frequency assignments estimated to be made available by initiative: 12 Terminal

Implementation Schedule:

Develop talking points on this issue for a meeting with the Executive Secretary, DOD PBFA: Completed, May 2001

Meet with the Executive Secretary, DOD PBFA, to pursue this issue: Completed, May 2001

In the meeting held May 3rd, the Executive Secretary, DOD PBFA, endorsed the idea that the DOD would carry out a spectrum audit on VHF air-ground usage. A meeting was held on June 4th with DOD spectrum planners; they were in the process of completing a directive for the Executive Secretary, DOD PBFA, to have DOD conduct the audit.

Meet with the Executive Secretary, DOD PBFA, in a follow-up meeting to consider the results of the DOD frequency audit: TBD

16) Investigate use of VOR frequencies for AWOS and ASOS broadcast function only.

Summary of proposed action:

The objective of this improvement measure is to consider the potential of using VOR frequency assignments to implement VHF ground-to-air broadcast transmitters for AWOS and ASOS, thereby freeing up frequencies within the 118-137 MHz band to satisfy other ATS requirements. Tests would be needed to determine suitable ground transmission power and antenna polarization characteristics, so that the VOR receivers in the aircraft could receive the voice broadcasts satisfactorily within the defined service volumes. It is recognized at the outset that frequency allocation issues would need to be addressed, since this improvement measure proposed to use frequencies allocated for navigation services solely for communications purposes.

Coordination/Financial Support/Technical Support Necessary:

Coordination between the FAA Technical Center, conducting the testing, and ASR and the FMOs, would be needed to ensure that the testing and results reflected realizable ground site capabilities and a satisfactory service, respectively. Sizable test costs could be expected, since aircraft flight costs would be incurred, unless the tests could be incorporated on other test flights. If deemed feasible, further coordination will be necessary with other FAA offices. In addition, coordination will be necessary with the NTIA, the FCC, and ICAO on the frequency allocation issue.

Expected Improvement (Additional Assignments, Assignment Flexibility, etc.):

Number of frequencies made available by initiative: 11

Possible AWOS/ASOS assignments: 122 X 11 = 1342

Implementation Schedule:

ACB conduct and report on preliminary bench tests to determine the basic feasibility of this improvement measure: Completed, February 2001

During the early preparation for the bench testing, it was determined that the Motorola CM-200 does not tune below 118 MHz, and, therefore, would not be usable in this application. The ITT AN/GRT-21 transmitters tune down to 116 MHz. Tests were performed with the ITT transmitter and five avionics transceivers–four general aviation and one air carrier transceiver. Different levels of modulation (30% and 90%) and desired signal levels were tested. The ITT transmitter was adjusted for 2.5 watts and then attenuated to the test signal levels. These signal levels corresponded to distances between 62 NM and 100 feet. Voice recordings were also made at each test condition. The bench test demonstrated the feasibility of using VOR frequencies for AWOS and ASOS broadcasts. Follow-on flight tests would be needed to test the performance of the vertically polarized ground communications transmit antenna and the aircraft's horizontally polarized VOR antenna.

ACB conduct and report on additional bench tests with 60 percent modulation: Completed, March 2001

ACB develop flight test plan and for testing the performance of the vertically polarized ground communications antenna used in conjunction with the aircraft's horizontally polarized VOR antenna, and send to ASR for review: Completed, February 2001

ASR provide comments to ACB on flight test plan: Completed, February 2001

ACB conduct flight testing: Completed, March 2001

Satisfactory performance was not attained during the flight testing with the vertically polarized ground antenna. Analysis of the data showed that a circularly polarized antenna should solve the coverage problems encountered during the flight testing. An Antenna Products DPR-4A (FA-5675 "swastika antenna") was ordered and received. ACB recommended the installation of this antenna at the ground station and that the flight tests be rerun.

ACB conduct flight testing with the circularly polarized ground antenna: Completed July 2001

Satisfactory communications performance was demonstrated with 10-Watt transmitter power. As a result, ASR will pursue implementing this improvement measure.

ASR coordinate with the Weather Office, AVR, and AT on a new use of VOR frequencies for AWOS and ASOS: October 2002

ASR develop implementation policy and frequency assignment criteria for use of VOR channels: December 2002

ASR ensure the Aeronautical Information Manual is updated as necessary to avoid pilot confusion in the use of voice communications only on VOR channels: TBD

ASR conduct initial coordination with NTIA and the FCC to address the frequency allocation issue: TBD

ASR conduct coordination with ICAO to address the frequency allocation issue: TBD

17) Investigate use of offset carrier operation for high altitude and ground service.

Summary of proposed action:

The objective of this improvement measure is to consider the possibility of using offset carrier operations for very large sectors where a single ground site cannot provide adequate coverage. Presently, in such coverage situations, either two or more frequencies or selective keying (see Improvement Measure Number 18) are used to provide coverage. Using two or more frequencies is spectrum inefficient, and selective keying has been viewed by some as too labor intensive. With offset carrier operations, the currently used two or three ground transmitters (covering a large sector) tuned to different frequencies would instead be transmitting on the same frequency, with each of the transmitters tuned to, for example, + and – 6 kHz from the center frequency assignment. The receiver would automatically "lock onto" one of the offset carriers and suppress lower level signals on the same frequency. Such a frequency offset system might also be usable at large airports where ground control coverage blind spots exist.

The air carrier industry has used offset carrier operations in the provision of AOC for years. (Other countries, such as the United Kingdom, have also used offset carrier operations for ATS.) However, the major concern with using a frequency offset system in the NAS is the inadequate specifications of some general aviation radios. In these radios, an audio heterodyne tone is produced in the receiver from the carriers of the two or three transmitters. If this heterodyne falls within or close to the audio pass band of the receiver, the pilot will here a tone.

Analysis and tests will be conducted to determine the potential for implementation of this improvement measure in selected situations in the NAS.

Coordination/Financial Support/Technical Support Necessary:

Coordination among ASR, the FMO's, and ACB are necessary to consider the potential areas where this improvement measure can be implemented, and to conduct feasibility tests of this capability.

Expected Improvement (Additional Assignments, Assignment Flexibility, etc.):

Number of frequency assignments estimated to be made available by initiative: 15 Enroute and 15 Terminal

Implementation Schedule:

ACB conduct bench tests to determine the initial feasibility of using offset carrier operations in the NAS: Completed, January 2001

ACB tested three ITT transmitters, which were tuned to 127.025, 127.019, and 127.031 MHz (i.e., the center frequency, -6 kHz, and +6 kHz, respectively). Two air carrier and five general aviation transceivers were tested. The squelch on one of the general aviation receivers had to be disabled to receive the signal. The squelch of a second general aviation receiver was activated by the reception of the frequency offset signals and no audio was heard. Due to this squelch issue, the frequency offset concept would not be deemed feasible for ground control operations at airports which general aviation aircraft use. It may be useable in high altitude sectors where air carrier receivers are in use. Future work could include further testing with the three frequency offset. Real world situations could be simulated by, for example, setting one frequency to –87 dBm and then increasing and decreasing the other two frequencies.

ASR coordinate a meeting with ARINC to discuss offset carrier operations: Completed, June 2002.

ACB conduct final bench testing for offset carrier operations: Completed, February 2002.

ACB complete flight tests to validate offset carrier operations in the NAS for defined applications: October 2002

ACB develop criteria to implement offset carrier operations in the NAS for ATS: March 2003

ASR and FMO's review the draft criteria, provide comments, and develop final criteria: May 2003

Implement criteria for offset carrier operations in the NAS: TBD

18) Investigate the use of more select keying and voting systems, including reviewing the AT policy on simulcast transmissions.

Summary of proposed action:

The objective of this improvement measure is to gain an increased use of a single frequency to cover those large enroute airspace sectors that now use more than one frequency to obtain the needed coverage, thereby obtaining spectrum resources with which to satisfy other ATS requirements. The very large enroute airspace sectors require transmission from several remote communications air-ground sites (RCAG's) to obtain the needed coverage. Some of these sectors use transmitters at the RCAG's that are tuned to different frequencies; all the transmitters are activated when the controller wishes to talk, a function known as "simulcast transmissions". In many areas, a function known as "select keying" is used. All the transmitters are tuned to the same frequency, and the controller selects the transmitter to key when calling an aircraft (i.e., the controller must identify the aircraft that is calling and respond by selecting the appropriate RCAG site, usually the closest site to the aircraft). On the receive side, a "receiver voting system" is used when using a single frequency for the large sector. The present voting system in use is that incorporated into the Voice Switching and Control System (VSCS), which selects the first received signal from the RCAG receiver sites placed in the voting system. Obviously, "select keying" is more spectrum efficient.

Coordination/Financial Support/Technical Support Necessary:

Coordination among ASR, the FMO's, and AT are necessary to both address this issue and adopt, if possible, a revised policy to use "select keying" as the primary means for establishing coverage in large sectors where more than one communications outlet is needed.

Expected Improvement (Additional Assignments, Assignment Flexibility, etc.):

Number of frequency assignments estimated to be made available by initiative: 130 assignments

These assignments were allotted as follows: 50 to Enroute, 50 to Terminal, and 30 assignments credited to Improvement Measure 17 (offset carrier operations).

Implementation Schedule:

ASR gather information on how coverage in large sectors is provided, taking into consideration the viewpoints of, in particular, AF and AT: Completed, January 2001

Information on voting system use was gathered through meetings and telephone conversations held with AOS-520, AF, and AT representatives from various regions. Select keying used in conjunction with the voting system is in use to some extent throughout the NAS. In the Great Lakes Region, simulcasting on multiple frequencies, each located at a different RCAG site, was the primary method selected long ago to provide coverage in large sectors. Voting systems were tried, but did not meet with much success when used by AT. This situation has been in existence since before 1977 and exists today. In some low altitude sectors, the multiple frequencies listed for the sector are used by the centers to control traffic into and out of airports that are located in the sector area. This operation needs better definition and the operational licensing needs to be corrected to reflect the frequency usage. Multiple frequencies that are being simulcast in the same sector should be candidates for VSCS receiver voting and select keyed transmitter operation. A careful review of the air traffic operations and any unique AT requirements which caused these operations to be licensed needs to be undertaken, and, where possible, they should be replaced by a voting system. It should be noted that simulcasting on multiple frequencies is used in a number of regions to some extent.

ASR ensure that the simulcasting issue is addressed in the AT frequency audit (Improvement Measure Number 11): Completed, August 2001

AGL-470 develop a memo that notes that single-sector multi-frequency simulcast is spectrum inefficient, and any assignment of more than one frequency per sector shall be operationally justified: October 2002

ANM prepare a statement of work to investigate the potential benefit of synchronizing transmissions from multiple sites to allow a phase locked operation: TBD

ASR task Mitre to research possible solutions for the coverage of large areas, or other areas, where it is not possible to provide suitable coverage from a single ground site: Completed, November 2001

No new practical solutions were uncovered as a result of this survey.

ACB consider the operational suitability of possible solutions for providing coverage to large areas, or other areas, where it is not possible to provide suitable coverage from a single ground site: TBD

19) Investigate lowering ground control transmitter antenna height and power output, if possible and practical, provided necessary coverage is maintained.

Summary of proposed action:

The objective of this improvement measure is to gain improved spectrum use efficiency and a reduction in RFI problems, by potentially lowering the height of ground control (GC) antennas and establishing a minimum transmitter power of 2.5 or 5 Watts. Studies and appropriate action are being taken to effect this improvement.

Coordination/Financial Support/Technical Support Necessary:

Coordination between ASR and the FMO's will be needed to discuss the situation of the actual installations in the field. Subsequent coordination will be needed with ANI to reach agreement on following the GC installation criteria.

Expected Improvement (Additional Assignments, Assignment Flexibility, etc.):

Number of frequency assignments estimated to be made available by initiative: 10 Terminal

Implementation Schedule:

ASR conduct a study of several airports, and a distance of 70 NM around these airports, with a view of examining the GC frequencies and the antenna heights used: Completed February 2001

It was considered from the study that GC antennas should not be higher than the antenna heights on commercial aircraft (found to be between 20 and 43 feet) using the GC service at the facility. Thus, it was concluded that GC antenna heights above 50 ft were not reasonable or acceptable, unless the circumstances could be justified by some coverage problem and on the basis of not causing RFI to adjacent airports. In summary, GC antennas should be at the minimum required height for effective communications with aircraft. In addition, the minimum required transmitter power should be used.

ASR draft revised guidelines for GC antenna installation, and distribute to ANI and FMO's for comment: October 2002

FMO's complete review of revised guidelines for GC antenna installation, and provide comments to ASR: November 2002

ASR meet with ANI to communicate the new guidelines for GC antenna installation, to reinforce the importance of following these guidelines, and highlight other issues: December 2002

20) Investigate the advantages resulting from the optimization of the ground equipment geographical location with respect to the service volume.

Summary of proposed action:

The objective of this improvement measure is to take advantage, if possible, of the increased spectrum use efficiency that would result from implementing more optimally spaced RCAG's within their associated service volumes. Presently, the location of the RCAG's are rarely within the center of their associated service volumes. Study will be undertaken of a number of geographic areas to evaluate the differences in distances between existing RCAG's and more optimally spaced RCAG's (which would occur from the implementation of ideally centered RCAG's within the coverage volumes). The end result of this improvement measure, if implemented, would be increased "packing" of the frequency assignments, reflecting improved spectrum use efficiency. While this measure may not be cost beneficial to move a large number of communication sites to the center of their respective service volumes, some gain could be expected for selected site changes where frequency congestion is a problem, and for the implementation of new sites.

Coordination/Financial Support/Technical Support Necessary:

Close coordination between ASR and the FMO's, and subsequently among ASR, ANI, and AT, would be necessary to fully discuss this measure, and ensure that the new guidance material for ANI usage is as complete and clear as possible.

Expected Improvement (Additional Assignments, Assignment Flexibility, etc.):

Number of frequency assignments estimated to be made available by initiative: 10 Enroute

Implementation Schedule:

ASR conduct a study to determine the potential of implementing RCAG's at the center of their respective service volumes: Completed, March 2001

A significant potential gain was indicated in studying 30 tailored service volumes (TSV's). The analysis ignored existing undesired emissions and did not use terrain analysis software. However, it was concluded that from a theoretical standpoint, an increase in frequency assignment efficiency could be gained by having all TSV ground communication sites centered in their respective service volumes. Due to such considerations as cost and other variables, it was recommended that only new RCAG sites should be considered, and then on a case by case basis with very close coordination with AT. In addition, it was recognized that some gain could be expected for selected site changes where frequency congestion is a severe problem.

ASR draft new engineering guidelines, if appropriate, for new or relocated communications sites for use by ANI. October 2002

ASR meet with ANI to establish the new engineering guidelines for new or relocated communication site installations: October 2002

21) Modify the AFM database to accept additional data and modify the frequency assignment model to work with these new data.

Summary of proposed action:

The objective of this measure is to both improve spectrum use efficiency and reduce the potential for co-site interference problems, by providing additional data in the AFM with which to make a frequency assignment. Such data as transmitter/receiver antenna locations and heights, the installation and impact of multi-couplers and combiners would be candidates for such data. In some situations it may be possible to reduce the 500 kHz co-site frequency assignment constraint.

Coordination/Financial Support/Technical Support Necessary:

Close coordination would be needed between ASR and the FMO's to fully consider the possible data that might be included in the AFM, taking into consideration such issues as the complexity and usefulness of the candidate data.

Expected Improvement (Additional Assignments, Assignment Flexibility, etc.):

Number of frequency assignments estimated to be made available by initiative: 10 Terminal

Implementation Schedule:

ANM serve as the focal point and develop a candidate set of data to be considered for implementation in the AFM: October 2002

ASR conduct a final review of the candidate set of data with the FMO's: November 2002

Prepare an AFM software change request to incorporate the candidate data set: January 2003

Distribute the software change request to the FMOs for review and comment: January 2003

Complete the review and integration of comments into the final software change request: February 2003

Complete the modification of the AFM to include the candidate data set: April 2003

Communicate this change to the FMOs: April 2003

22) Improve coordination with ARINC and obtain a more accurate database from them.

Summary of proposed action:

The objective of this improvement measure is to obtain a more detailed periodic database of frequency assignments from the ARINC master file. In particular, the location of the transmission sites around major airports would be helpful in making ATS requirements, reducing the potential for radio frequency interference, and in determining the source of some cases of radio frequency interference.

Coordination/Financial Support/Technical Support Necessary:

Coordinate with the ARINC spectrum management staff to determine if additional coordination and a more frequent exchange of frequency assignment databases might be possible.

Expected Improvement (Additional Assignments, Assignment Flexibility, etc.):

Number of frequency assignments estimated to be made available by initiative: 10 Terminal

Implementation Schedule:

In early coordination with ARINC (March 2000), it was learned that ARINC does not keep a file of the locations of the transmitting antennas around the airports. The reason given for this is that the users are frequently moving their antennas around. Additional workload and related cost would be required to keep track of all the location changes of the many users at each major airport. However, the potential benefits for implementing these measures for at least selected large terminals where severe frequency congestion exists may far outweigh the workload and costs to implement them.

ASR coordinate a follow-up meeting with ARINC to more fully discuss this improvement measure: Completed, January 2002

As a result of this meeting, ARINC has a better understanding of FAA's problems, and at selected airports where frequency assignment congestion is severe, ARINC might be able to get the locations and transmitted powers of the aeronautical operational control related ATS VHF air-ground outlets. ASR plans a phased approach in this regard, with the objective of initially gaining information on Atlanta Airport (ATL): Continuing

23) Revise the air/ground model to accommodate a 0.6 nautical mile vertical separation.

Summary of proposed action:

The frequency assignment criteria relating to how close to assign adjacent channels (i.e., the service volumes for adjacent 25 kHz frequency assignments) includes a horizontal minimum separation distance between the outer edges of the service volumes by 0.6 nautical miles. However, no similar minimum separation distance has been established for vertical separation of the service volumes of adjacent channels. The purpose of this improvement measure is to implement and allow a vertical minimum separation distance of 0.6 nautical miles between the service volumes of adjacent channels. This improvement is expected to yield a sizable spectrum use improvement, since this would allow, in many cases, the assignment of adjacent channels in the same geographical area.

Coordination/Financial Support/Technical Support Necessary:

An AFM software change to effect the inclusion of a 0.6 nautical mile adjacent channel vertical separation element will need to be drafted, coordinated with the FMOs, and submitted to the system automation support contractor for the change to be made. Subsequent coordination with the FMOs will be needed to ensure that they know this new capability has been implemented in the AFM.

Expected Improvement (Additional Assignments, Assignment Flexibility, etc.):

Number of frequency assignments estimated to be made available by initiative: 23 Enroute and 20 Terminal

Implementation Schedule:

Prepare an AFM software change request: Completed, May 2001

ASR communicate a policy letter to regions on this decision: Completed, June 2001

Complete the modification of the AFM to include a 0.6 nautical mile adjacent channel vertical separation criterion: Completed, December 2001

Communicate this change to the FMOs: Completed, December 2001

Revise Order 6050.32 to include the 0.6 nautical mile adjacent channel vertical separation criterion: June 2003

24) Combine HIWAS and ASOS/AWOS service on VOR channels.

Summary of proposed action:

The objective of this improvement measure was to investigate the possibility of combining Hazardous In-flight Weather Advisory Service (HIWAS) and Automated Weather Observing System (AWOS)/Automated Surface Observing System (ASOS) on a single VHF Omni Range (VOR) channel, taking into account operational and technical issues.

HIWAS is a continuous broadcast of in-flight weather advisories. It is an additional source of hazardous weather information; it is not a replacement for preflight or in-flight briefings. AWOS, increasingly being installed at airports, uses various sensors and a transmitter to broadcast local minute by minute weather data directly to pilots. Computer generated voice is used in AWOS to automate this information. The service volume for AWOS transmissions is 25 NM from the AWOS site and a maximum altitude of 10,000 feet above ground level (AGL). The system transmits a 20 to 30 second weather message, updated each minute. ASOS is a similar broadcast service jointly supported by the National Weather Service (NWS), the FAA and the Department of Defense (DOD).

Study concluded that while it may be technically possible in some areas to piggyback the AWOS/ASOS signals with HIWAS information and transmit it on a single VOR carrier, it was considered that the costs versus benefits would not warrant further consideration of this measure. Further there was a lack of support for this measure from AT and pilots (users were opposed to interruptions of the HIWAS transmissions for AWOS/ASOS). Other considerations included: (1) the need to ensure that the VOR would have the coverage needed by the other proposed services, (2) the need for communications links to interface AWOS/ASOS services with VOR transmitters, and (3) the question of which AWOS/ASOS information would get prioritized in a metroplex area where there was only one VOR.

25) Modify the air-ground model to give results by distance ratio instead of frequency order:

Summary of proposed action:

The objective of this improvement measure is to modify the air-ground model (the AFM) so that users of the model will be presented with a list of possible frequency choices by distance ratio. That is, when seeking to make a frequency assignment, the user will be presented with the lowest possible distance ratio between the new service volume and that of an adjacent one as the first frequency of choice, with higher distance ratio possibilities presented further down on the list. Previously, the user had to take additional steps to find the lowest distance ratio, which they did not always do. This improvement will help ensure that the frequency assignments are "packed" as tightly as possible, helping to ensure the best spectrum use efficiency.

Coordination/Financial Support/Technical Support Necessary:

An AFM software change will need to be drafted, coordinated with the FMOs, and submitted to the system automation support contractor for the change to be made. Subsequent coordination with the FMOs will be needed to ensure that they know this new capability has been implemented in the AFM, thereby helping to reduce the time needed to make a frequency assignment, and ensure the best possible spectrum use efficiency in making frequency assignments.

Expected Improvement (Additional Assignments, Assignment Flexibility, etc.):

None. The reason for this is that this practice is being carried out today in a manual manner.

Implementation Schedule:

Prepare an AFM software change request: Completed, June 2001

Complete the AFM software change: Completed, July 2001

Communicate with the FMOs regarding the AFM software change:
Completed, August 2001.

4. Summary of gain from the 25 improvement measures

4.1 Table A1.2-1 below presents a status summary of the 25 improvement measures to date. The improvement numbers in the table conform to the improvement numbers as they have been addressed above in this appendix.

Table A1.2-1: Status Summary of the 25 Improvement Measures (End of FY-2002)

Improvement Measure		FY – 2002		
		No. of Channels Gained	No. of Assignments Recovered	No. of Assignments Made**
1	121.5 MHz Guard Band	4	---	2
2	Flight Check Frequencies	---	---	---
3	Law Enforcement Chs.	1	---	1
4	Review FCC Plan	---	---	---
5	FSS Chs.	3	---	---
6	136 - 137 MHz	---	---	---
7	Rev. Standard Service Volume	N/A	---	---
8	Directional Antenna*	N/A	N/A	N/A
9	AWOS / ASOS sub-band	N/A	---	---
10	Grnd Control sub-band	N/A	---	---
11	ATS Freq. Audit	N/A	43	9
12	Improved Co-site Mitigation	N/A	---	---
13	Review Air Show	N/A	---	---
14	Review Firefight.	N/A	---	---
15	DOD use 126.2 / 134.1 MHz	---	---	---
16	VOR use for AWOS / ASOS	---	---	---
17	Offset carrier	N/A	---	---
18	Incr. Select Key / Voting Sys.	N/A	---	---
19	Lower Gnd Ctl. Tx Pwr/Ant. Ht.	N/A	---	---
20	Optimization site location	N/A	---	---
21	Mod. AFM to Accept Add. Data	N/A	---	---
22	Improve Coord. w/ ARINC	N/A	---	---
23	Accom. 0.6 Nmi Vert. Sep.	N/A	---	---
24	HIWAS/ASOS/AWOS on VOR*	N/A	N/A	N/A
25	A/G Model Ch. for Dist. Ratio	N/A	---	---
	Yearly Totals:	**8**	**43**	**12**

Notes:
* Measures that are not currently being pursued.
** Based on only new requirements in current year.

Basic Principles of Transition to the Future System

1. Introduction

1.1 The purpose of this appendix is to provide additional information on the basic issues regarding the transition from the present very high frequency (VHF) air-ground voice communications system to the future system. The present voice system is based on double-sideband amplitude modulation (DSB-AM) and provides a single voice circuit on each 25 kHz radio frequency channel. The future system, known as VHF Digital Link (VDL) Mode 3 (VDL Mode 3), is based on time division multiple access (TDMA) and provides four independent communications circuits on each 25 kHz radio frequency channel. The four circuits can be any mix of voice and/or data link circuits. At the end of this appendix, in Section 3, a discussion of a possible alternative to VDL Mode 3 is presented; this alternative includes a channel split to 8.33 kHz DSB-AM for increased voice capacity and the use of VDL Mode 2 for data link.

2. Consideration of a systematic implementation of VDL Mode 3

2.1 As the year 2010 approaches, plans to implement the future VHF air-ground communication system, VDL Mode 3, will be completed. The early implementation of the future system in 2010, it is presently assumed, will concentrate on voice communications. However, VDL Mode 3 is designed to provide voice and data link communications to an aircraft in a functionally simultaneous manner on the same 25 kHz channel, using a single antenna and radio. The transition must be carried out in a phased approach, taking into consideration the equipage of the airspace users and the types of sectors to be implemented first. However, prior to any operational implementation, initial testing must be completed to validate the performance of the future system.

2.2 It is anticipated that the commercial aircraft, and other aircraft that fly in the upper airspace, will be the first class of aircraft to be equipped with the future system. This stems in large part from the basic multi-mode radio design: that is, the same radio design (i.e., modulation, digital transmission rate, transmission power, etc.) used for VDL Mode 2 data link will also be used for the future VHF system (VDL Mode 3). Thus, the upper airspace users that are beginning to equip to operate with VDL Mode 2 data link in the 2002 time period are considered to be the first class of users to be able to operate with the future system (VDL Mode 3). Thus, the initial transition to the use of the new system is likely to be in the high altitude enroute sectors.

2.3 There will not be sufficient spectrum available to be able to provide access to both the present DSB-AM system and the VDL Mode 3 system in the same airspace even in the early operational implementation of the future system. Thus, all users in a sector implemented to operate on VDL Mode 3 must have a radio equipped to operate with this new system capability. It is assumed that the airspace user flying in a VDL Mode 3 sector will have a multi-mode radio capable of operating on DSB-AM voice and VDL-3 voice. As the user tunes the radio to the channel identifier provided by the controller, the radio automatically changes to the appropriate voice mode (DSB-AM or VDL Mode 3). In this manner, the user's flight into an upper airspace sector implemented with the new VDL Mode 3 voice service should be transparent to the pilot and controller (except for the new channel "numbering" for VDL Mode 3).

2.4 The implementation from the ground radio standpoint will be based on studies to identify several high altitude sectors, which might be serviced from the same ground location. (It should be noted, however, that a ground system transmission timing synchronization capability could allow other circuits on the same 25 kHz channel to be used at other ground locations in the same area.) The first implementation might be to only replace one DSB-AM sector with VDL Mode 3. In this case, only one-fourth of the VDL Mode 3 capacity would be used. If the transition of that sector went smoothly, then another circuit of the same 25 kHz VDL Mode 3 channel could be used to replace another DSB-AM sector which could be covered from the same location. In this case, one 25 kHz channel would be "freed-up" to be used elsewhere for a DSB-AM service, or to be used in the transition plan. At this point, only two circuits of the 25 kHz VDL Mode 3 channel capacity would be used. The remaining two circuits could be used as a reserve, used to add additional voice services, or used later to provide data link to the two sectors provided with the voice service (e.g., one voice and one data link circuit in each sector).

2.5 Subsequent transition to VDL Mode 3 would extend to completing the implementation in the upper airspace, followed by selected low altitude sectors and terminal applications. Follow-on transition to data link applications would be possible. The extent and timetable of the VDL Mode 3 transition will be the subject of future planning.

3. Consideration of the possibility of an alternative implementation

3.1 Another option for providing ATS air-ground voice communications for the future would be to use the current DSB-AM technology, but with narrower channels 8.33 kHz wide. This "channel splitting" was used in the past to create more channels when additional spectrum resources were needed to satisfy a growing air-ground frequency assignment requirement. The last such split (from 50 kHz to the current 25 kHz channels) was adopted in 1977. There were many reasons why the 8.33 kHz option was not selected as the future system candidate during the extensive RTCA and ICAO studies of potential systems to satisfy future air-ground voice communication requirements. It is not a digital-based implementation, thus the 8.33 kHz option does not offer any new benefits, such as security, automated handoff, and other improvements that could increase the efficiency of the NAS.

3.2 In addition, many RCAG sites have the maximum number of transmitters possible, within the constraint of implementing good co-site engineering practices (i.e., ensuring that there will not be interference from many transmissions at one site). Therefore, the implementation of 8.33 kHz, resulting in many more radio frequency channels (with one communications circuit per 8.33 kHz channel) than VDL Mode 3 (with four communications circuits per 25 kHz channel), would likely require construction of additional RCAGs, at high cost, to achieve a capacity increase benefit.

3.3 The VDL Mode 2 data link system was designed concurrently with VDL Mode 3. The two systems reflect only minor hardware and software differences. This was done to have a high degree of commonality between the ATS and AOC equipment used on modern civil aircraft. VDL Mode 2, however, was optimized for the long AOC type messages by creating one 25 kHz wide data channel for high data rates. In contrast, VDL Mode 3 was optimized for the typically short ATS messages, and each 25 kHz radio frequency channel was split into four independent communication circuits which could be used to simultaneously satisfy the requirements of any mix of up to four voice and/or data link circuits.

3.4 AOC messages, by nature, are a single priority. That is, they can be accommodated on a "first-come, first-served" basis. ATS messages, however, come in a variety of priorities. For example, time critical ATS messages include distress and emergency messages. Non-time critical ATS messages include some types of weather advisories and routine clearance messages. Therefore, one of the requirements of the ATS air-ground communications system is the capability to prioritize the messages awaiting transmission, and, if necessary, preempt a transmission in progress to immediately transmit a higher priority message. VDL Mode 2 does not have this capability.

3.5 In addition, the design of VDL Mode 2 reflects a probabilistic design for the transmission of messages, which does not prevent the transmission of messages from different locations during the same time period. This leads to “message collisions”, resulting in message transmission delays (which is a result of the time that it takes the system to recognize that the messages have not arrived at their destination, and until the affected messages can be resent and received). In contrast, VDL Mode 3 has been designed from the outset to provide a deterministic means of ensuring the transmission and arrival of messages, in which, to the highest degree possible, the communication delays can be systematically determined.

4. Concerns linked to early implementation of ATS data link communications

4.1 As an interim step towards integrating data link into the ATS communications system, the FAA has decided to initially implement a non-time critical subset of the controller-pilot data link communications (CPDLC) messages via a service provider using VDL Mode 2. (After implementation of VDL Mode 3, these CPDLC messages would be transmitted via the VDL Mode 3 system.) While the service provider claims to be able to satisfy all known ATS data message delivery requirements, by using the excess capacity of the newly implemented VDL Mode 2 system, there are several spectrum issues that must be addressed. As more CPDLC messages are added to VDL Mode 2, there will likely be additional FAA requirements for latency (message delivery time) and availability. There is a concern that the service provider has not taken into account these new requirements when determining the capability of and the spectrum needs for the AOC messaging system.

4.2 AOC VDL Mode 2 data messaging is currently limited to 20 channels which could rapidly be used up if data messaging continues to experience rapid growth. Because of severe congestion in the ATS bands, it would be very difficult, and it may not be feasible at all, to use ATS channels to accommodate this data link growth. Yet another issue is the lack of priority and preemption capability on the VDL Mode 2 system, which could result in constraints on its use by air traffic controllers. These and other issues will need to be addressed as a VDL Mode 2 based CPDLC implementation begins.

References for Section 1

1.1 "Recommendations of the NEXCOM Aviation Rulemaking Committee to the Federal Aviation Administration", September 2001.

1.2 "A Study of the Potential Benefits to be Derived from the 23 (Plus 2) VHF Air-Ground Communications Improvement Measures", by ASR, September 2001.

Section 6 - Navigation Requirements

6.1 Introduction

6.1.1 The navigation capability forms a critical part of the communications, navigation, and surveillance triad that allows air traffic control to operate in a safe and efficient manner within the National Airspace System (NAS). Typically, the pilot is issued an airspace clearance via air-ground communications to fly a specific route and altitude profile. The pilot is responsible for ensuring that his/her aircraft follows the clearance instructions using the appropriate aeronautical radionavigation system capabilities available in the NAS. (In contrast, surveillance is the capability that is used to check on the progress of the aircraft to help ensure, inter alia, that the aircraft is following the clearance instructions and not deviating into a potentially dangerous situation.) Thus, it is clear that the navigation function plays a very important role in the NAS. It should be noted that there are aircraft self-contained navigation systems, specifically the Inertial Navigation System (INS); however, most of the navigation services provided in the NAS are via radio systems operating within the aeronautical radionavigation service (hereafter called ARNS).

6.1.2 The need for better accuracy, capabilities for new applications, and an increased area of coverage has resulted in the implementation of a large number of navigation systems requiring a significant amount of radio frequency spectrum. In addition, because of the critical nature of the navigation services, their operation is dependent on the availability of interference free radio spectrum. There is a continuing pressure for more and newer ARNS systems at many airports within the NAS. While the Airway Facilities Service is doing its utmost to help satisfy the continued demand for navigation services, without analysis it is not clear whether the radio spectrum resources exist to satisfy all the new requirements. This navigation system spectrum plan is a support element of the FAA's Capital Investment Plan (CIP) and Operational Evolution Plan (OEP).

6.2 Purpose

6.2.1 The purpose of this plan is to ensure, to the extent possible, that the future spectrum requirements for ARNS system implementations to the year 2010 can be satisfied.

6.3 Background

6.3.1 Over the past half century, the implementation of a broad system of ARNS installations has been carried out to satisfy enroute, terminal, non-precision approach, and precision approach requirements. This implementation has required a significant amount of radio spectrum resources in a number of frequency bands across the spectrum. Factors relating to the amount of radio frequency spectrum needed include the number of systems to be implemented and the required frequency engineering criteria. The frequency engineering criteria is a complex set of parameters determining how close stations on the same channel or adjacent channels can be placed geographically, as well as preventing radio frequency interference (RFI) from other systems.

6.3.2 The geographic area for which the radio service from each navigation facility is protected is called the Frequency Protected Service Volume (FPSV). In order to extend the coverage of facilities, Expanded Service Volumes (ESVs) are established in many cases using specific frequency engineering criteria. It should be noted that all established air routes, including random air navigation (RNAV) routes, must be within the FPSVs engineered for the facility or facilities being used to service the routes.

6.3.3 The worldwide interoperability requirement for ARNS systems is satisfied by requiring that the system standards and frequency engineering criteria adhere to International Civil Aviation Organization (ICAO) standards and recommended practices. In addition, the navigation systems must conform to U.S. regulations, including National Telecommunications and Information Administration (NTIA), Federal Communications Commission (FCC), and FAA regulations, technical standards, and service requirements, as appropriate.

6.3.4 It is becoming increasingly difficult to satisfy the future requirements to implement additional facilities for existing navigation systems and the new navigation systems with the limited amount of available radio frequency spectrum. Many of the new system capabilities must be squeezed into radio frequency spectrum that is already being used by existing systems. The new systems include the Global Positioning System (GPS) L1 and L5 civil signal capabilities, the GPS Wide Area Augmentation System (WAAS), the GPS Local Area Augmentation System (LAAS), the Universal Access Terminal (UAT), and the Transponder Landing System (TLS). Further, spectrum management issues exist, as highlighted in the next section, that impact facility or system implementation. Thus, it is extremely important to closely manage the remaining spectrum resources.

6.4 ARNS spectrum management issues, future requirements, and the satisfaction of future requirements

6.4.1 Introduction

6.4.1.1 The spectrum management issues, future requirements, and the satisfaction of future requirements are presented, to the extent possible, on a frequency band basis, starting from the lowest frequency band used by ARNS facilities. The study included the consideration of the following ARNS systems and system elements:

1. Non-Directional Beacon (NDB)
2. Instrument Landing System (ILS) Marker Beacons
3. Instrument Landing System (ILS) Localizer
4. Very High Frequency Omni-directional Range (VOR)
5. VOR Test (VOT) Facilities
6. Ramp Testers
7. Local Area Augmentation System (LAAS)
8. Special Category One System (SCAT-1)
9. Transponder Landing System (TLS)
10. VHF Digital Link, Mode 4 (VDL-4)
11. ILS Glideslope
12. Distance Measuring Equipment (DME)
13. Tactical Air Navigation (TACAN) System
14. Universal Access Terminal (UAT)
15. Global Positioning System (GPS)
16. Wide Area Augmentation System (WAAS)
17. Microwave Landing System (MLS)

6.4.1.2 The statement of navigation service requirements to the year 2010 are still evolving. Those requirements that are known to date will be highlighted in this section. A consideration of whether these known requirements can be satisfied are based on the results of frequency engineering carried out to date, and a projection, if possible, on whether it is believed that there are sufficient spectrum resources available to satisfy any requirements that have not been frequency engineered.

6.4.1.3 From a spectrum management viewpoint, the primary focus on satisfying new navigation service requirements is whether sufficient spectrum is available to make frequency assignments to allow specific facilities or systems to satisfy the intended navigation service requirements (including the locations and service volumes). Thus, the future navigation service requirements will be examined from a navigation system standpoint, rather than from whether the requirement is an enroute, terminal, non-precision approach, or precision approach service requirement.

6.4.2 190-535 kHz NDB band

6.4.2.1 Frequency assignment congestion: There are a large number of beacons assigned in the available spectrum, thus it is very difficult to make new frequency assignments. There are presently a total of 1889 NDB frequency assignments in this band, of which the majority, 1065, are non-FAA assignments.

6.4.2.2 Voice quality: Many NDBs are presently used as voice outlets for AWOS, ASOS, and other broadcast services. It is difficult to obtain adequate voice quality using an NDB. A contributing factor is the narrow bandwidth of the transmitting antenna, which can cause distortion of the voice signal. NDB voice is also susceptible to a significant amount of noise, which is inherent to the NDB frequency band. In addition, the use of voice on NDBs reduces the amount of spectrum available for NDB navigation services, since a greater bandwidth is required to provide NDB voice services.

6.4.2.3 Longevity of NDBs: Many of the FAA supported system of NDBs have been operational for many years. While these systems continue to age, the potential of new systems, in particular GPS, have led planners to believe that in the very near future NDBs may be able to be decommissioned. However, users continue to voice the need for the present system of navigational aids (in particular, NDBs have been needed in Alaska to provide weather information).

6.4.2.4 Expansion of maritime differential GPS facilities: The maritime community uses radio beacons as a source for disseminating differential GPS information to users within the coverage areas of the beacons. This service is implemented in a maritime portion of the frequency band, where some FAA NDBs are implemented. The expansion of this maritime differential GPS service has required the FAA to move NDBs out of the maritime portion of the band, resulting in increased frequency assignment congestion.

6.4.2.5 Future NDB requirements and spectrum availability: The future requirement for NDBs is anticipated to be mostly for non-Federal systems. However, some new ILS installations may have compass locator beacons associated with outer markers beacons (known as LOMs, an NDB service) associated with them. In summary, a significant future NDB requirement is not expected, and, thus, it is considered that there will be sufficient spectrum resources available to satisfy the new NDB requirements.

6.4.3 75 MHz marker band

6.4.3.1 There is a single frequency channel in the 75 MHz band, serving ILS outer, middle, and inner marker beacons, whose purpose is to alert the pilot (via a receiver on the aircraft) of his/her progress along an ILS approach. There are currently 1603 FAA and 176 non-FAA marker beacon frequency assignments in this band.

6.4.3.2 Interference to some consumer TV receivers: Some older TV receivers are susceptible to interference from marker beacons, due to the closeness of the marker beacon channel to nearby TV channels. However, this problem is only noted when such TVs are in operation in close proximity to the marker beacon operations.

6.4.3.3 Use of Marker frequency for runway incursion prevention: System developers are considering the use of the marker beacon receiver capability on the aircraft for runway incursion prevention. In such use, a low power marker beacon-like signal would be transmitted at key points in the runway/taxiway system to alert pilots when they are about to enter/exit certain points. Care must be exercised to ensure that such usage would not interfere with the present marker beacon function.

6.4.3.4 Future Marker requirements and spectrum availability: The future requirement for Maker facilities will be consistent with the implementation of ILSs, since the Marker beacon transmitter is an element of the ILS. It is not anticipated that there will be any problems satisfying the future requirements for Marker beacon implementation. There is also a possible future requirement for the use of Marker beacon capabilities for runway incursion prevention.

6.4.4 108-118 MHz ILS/VOR band

6.4.4.1 Frequency assignment congestion: Frequency assignment congestion is the number one spectrum management issue with both the ILS Localizer and the VOR. This stems from the sizable number of systems that operate, or are planned to operate in the 108-118 MHz band. The present systems include the ILS Localizer, VOR, and SCAT-1 systems. There are 1117 FAA and 249 non-FAA ILS Localizer frequency assignments, and 981 FAA and 73 non-FAA VOR frequency assignments in this band. The possible new systems include the LAAS, TLS, and VDL-4. In addition, the implementation of VHF air-ground communications is being pursued in the upper portion of the band (see below). The congestion stems from two aspects, the large number of service requirements and the difficulty posed by the RFI potential of nearby high power FM broadcast stations (in particular to Localizers that operate in the lower, 108-112 MHz, part of the band).

6.4.4.1.1 A number of initiatives were undertaken over the years to reduce the frequency congestion the 108-118 MHz band. In the latter 1970s, both the ILS Localizer and VOR services introduced 50 kHz channel spacing (previously 100 kHz). However, General Aviation did not transition in a timely manner to the new 50 kHz spacing, and even today many General Aviation users support the use of 100 kHz channels. Other initiatives included reducing the standard service volume for ILS Localizer coverage from 25 nautical miles (NM) to 18 NM, and the same frequency (instead of separate frequencies) began to be used for “back to back” Localizer assignments (i.e., for two localizers serving the opposite approaches to a single runway). The FAA also planned to implement MLS, thereby freeing up spectrum in the 108-112 MHz band segment; however, the FAA decided in the late 1980s not to implement MLS in favor of new services supported by GPS.

6.4.4.2 <u>FM broadcast interference to VOR and ILS Localizer operations:</u> Both the ILS Localizer and VOR frequency bands begin at 108 MHz, the upper edge of the FM broadcast band. The closeness of the FM band and the high powers of many FM stations form the basis for potentially causing interference to VOR and ILS Localizer operations. Interference is due to two primary causes. There is desensitization of the navigation receivers due to the brute force power of high power FM stations operating near to the 108 MHz band edge. In addition, FM signals can mix in the front end of VOR and ILS receivers, resulting in the generation of a new signal that falls within the channel bandwidth of the desired navigation signal, thereby potentially providing misleading guidance to the pilot.

6.4.4.2.1 Under the Part 77 Airspace Process regulatory framework, any broadcasting service intending to change its present operation, or any new prospective broadcasting service, must file an advance plan with the FAA detailing such characteristics as the proposed transmitted power, antenna pattern, antenna height, etc. This process provides the information and time for the FAA to analyze the modified or new operation, to determine if there would be any potential for interference to ILS or VOR services, and to coordinate with the broadcast service and the FCC regarding the findings.

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6.4.4.3 <u>ICAO FM immunity requirements (FM immunity)</u>: In the latter 1980s and 1990s, ICAO, with U.S. participation, worked extensively on the development of new FM immunity standards to help ensure that ILS Localizer and VOR operations would be free from interference from FM broadcast stations. Those international standards have been in force for several years. However, the United States has not adopted these ICAO standards, and has filed an exception to the use of the new ICAO FM immunity standards. This action was taken as a result of recommendations made by the Aviation Rulemaking Advisory Committee (ARAC), which includes Government and industry representatives. In order not to require the equipage of new receivers in the large population of General Aviation aircraft, at great cost, it was decided by the ARAC to continue to protect the older radio receivers by using existing criteria. Thus, the FAA continues to protect radio receivers that do not satisfy the ICAO immunity requirements.

6.4.4.4 Localizer and VOR ESVs: While there is a very high level of frequency assignment congestion being experienced for new or modified Localizer and VOR services, it is even more difficult to satisfy requests for ESV coverage for these navigational aids. In particular, Localizer and VOR coverage areas that might have been established by very careful engineering, perhaps with changes in the service volumes or frequencies of nearby navigational aids, are nearly impossible to expand using the ESV criteria.

6.4.4.5 LAAS operations in VOR band: There is a continuing frequency assignment problem for VORs in the 112-118 MHz sub-band. In addition, it is planned that the new LAAS capability will also operate in this sub-band in the NAS. Until there is a meaningful de-commissioning of at least some VORs, it may become difficult to implement LAAS installations in this band beyond the present plan of 161 stations. Further compounding the problem, LAAS frequency assignments are being limited to below 117.2 MHz to protect the VHF air-ground communications in the adjacent band (118-137 MHz) from LAAS adjacent channel emissions.

6.4.4.6 LAAS standardized down to 108 MHz: While it is the intention to initially implement LAAS in the NAS in the 112-118 MHz sub-band, this system capability has been standardized by ICAO to operate in the 108-118 MHz band. The possible implementation of LAAS installations in nearby Canadian and Mexican border areas, in the 108-112 MHz sub-band, could impact the present ILS Localizer installations in the NAS.

6.4.4.7 ILS Localizer system interlock issue: In order to be able to conduct routine maintenance with the Localizer transmitting, it is desired to have the Localizers at the ends of the same runway transmit on different channels. However, due to the severe frequency congestion, in many cases both Localizers have been assigned the same channel. This has caused a significant Localizer maintenance issue, since maintenance technicians cannot routinely allow the non-operational Localizer to transmit at any time they may desire. It is thus necessary to conduct maintenance at off peak hours, when maintenance is not routinely conducted.

6.4.4.8 Aircraft without 50 kHz channel capability: Some aircraft that routinely fly into airports requiring ILS Localizer operations are not equipped with 50 kHz (200 channel) receivers. Thus, it is necessary to try and find (and continue to operate) ILS Localizer channels that fall on a 100 kHz center in such cases. This restriction compounds the frequency congestion situation, and sometimes limits the ability of the FAA to flexibly change channels to satisfy new nearby ILS requirements.

6.4.4.9 Two sets of receiver protection criteria: While the ILS/VOR channelization was changed from 100 kHz to 50 kHz channels in the late 1970s, the FAA has continued to protect the operation of the many thousands of, in particular, General Aviation 100 kHz

ILS/VOR receivers still in operation (i.e., receivers that only tune to the 100 kHz channels and have a wider, less stringent, receiver bandwidth). The protection of General Aviation 100 kHz receivers has required the use of two sets of frequency assignment criteria, "interim" and "final". The less spectrum efficient "interim" criteria must still be applied to protect the 100 kHz channel assignments. The FAA will need to continue to use this criteria until General Aviation transitions to 50 kHz receivers.

6.4.4.10 Pressure to seek VDL-4 operations in 108-112 MHz band: ICAO has assigned the VDL-4 to operate within the 118-137 MHz band; operation is also allowed in the 108-118 MHz band. The developers foresee a need for a number of channels, including several in the 108-118 MHz band. The intent seems to be toward reserving a number of 25 kHz channels for VDL-4 operations on a worldwide basis. Because of the severe frequency assignment congestion, it would be very difficult, if not impossible, to find a channel in 108-112 MHz for VDL-4 operations in the NAS. As a result of the Automatic Dependent Surveillance-Broadcast (ADS-B) link decision process, the FAA has decided not to implement VDL-4 in the NAS.

6.4.4.11 Ramp test frequencies: Designated frequencies have been established for normal ramp testing (VOR at 108.00 MHz and 108.05 MHz, and ILS Localizer at 108.1 MHz and 108.15 MHz). Since many FM broadcast stations operate close in geographic proximity to the test stations, the FAA has had to provide test frequencies from operational channels higher in the band to avoid the potential for interference to the test facilities from the FM stations. Careful coordination is required to ensure that these non-typical test frequencies do not cause interference to operational ILS services.

6.4.4.12 Possible expansion of VHF communications into the 112-118 MHz band: There is such a pressure to find additional spectrum resources to satisfy the varied and large requirements of VHF air traffic control communication services (that presently operate in the 118-137 MHz band), that consideration is being given in ICAO to expanding some of the air-ground communication services into the 112-118 MHz band. One possibility being given consideration is to move the band edge down one or several MHz from the present 118 MHz band edge.

6.4.4.13 Possible VHF ground-to-air broadcast communications in 112-118 MHz band: The FAA is considering, as one of the improvement initiatives in the VHF air-ground communications spectrum management plan, the use of VOR channels (not VOR transmitters) for ground-to-aircraft (one way) broadcast services, such as AWOS or ASOS. The signals, originating from a VHF communications transmitter on the ground, would be received on the aircraft by VOR receivers. Such a service would allow the user community to use, in a limited way, possible spectrum resources outside the 118-137 MHz band for air-ground communication services without re-equipping with new radios.

6.4.4.14 Future ILS localizer requirements and spectrum availability: The ILS localizer requirements for new installations presented in Figure 6.1 have been obtained from the FAA's OEP and from the FAA Office of Communications, Navigation, and Surveillance

Systems (AND) on Congressionally mandated ILS installations through FY-2002 (Congressionally mandated ILS requirements have not been received for the following years).

Figure 6.1

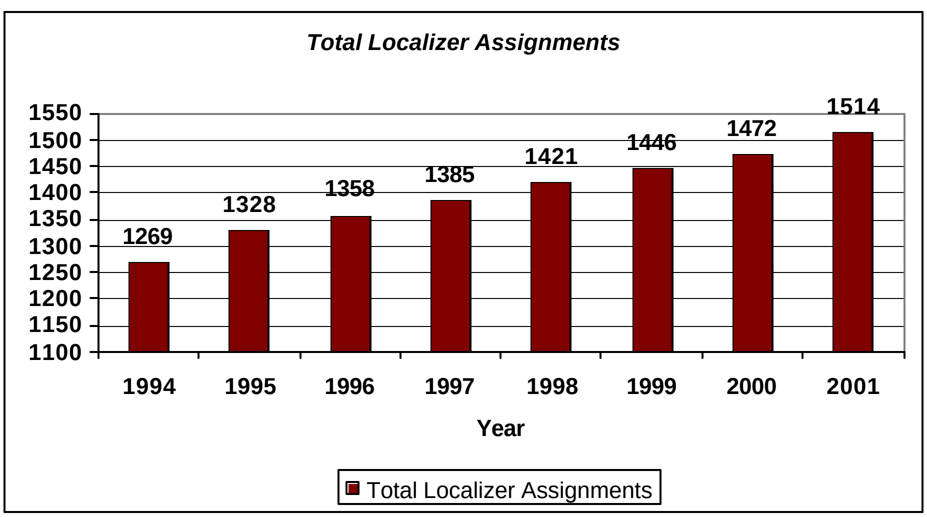
Future ILS New System Requirements

FY	2002	2003	2004	2005	2006	2007
OEP	2	3	3	3	1	3 (engineering completed)
AND	26 (for FY 2001/2002; 8 have been engineered to date)					

6.4.4.14.1 It is judged that there will be sufficient spectrum resources available to make the remaining frequency assignments for the FY-2001/2002 requirements. However, it would be extremely difficult, and most likely impossible, to make further ILS frequency assignments in some high traffic density areas, such as the New York City area. It is expected that there will be additional ILS implementation requirements for the years after FY-2002, beyond those identified in Figure 6.1. This stems from the history of new ILS installations over the years. Figure 6.2 shows that there have been at least 25 new installations each year since 1994 (including FAA, Department of Defense (DOD), and other Government and non-Government requirements).

Figure 6.2

Growth of ILS Localizer Frequency Assignments in the United States



6.4.4.14.2 If the historical requirement for about 25 new ILS (with DME) systems each year continues as expected, the frequency requirements for them will not be able to be satisfied at many locations. Thus, action needs to be taken at the earliest possible date if the life of the ILS system is to be extended.

6.4.4.14.3 One improvement could be to pursue requiring the user community to equip with 50 kHz channel receivers, possibly adhering to the new ICAO immunity standards (see also Section 6.4.4.9). For such a requirement to be acceptable to the user community, several years would need to be given to re-equip. Thus, consideration of this measure would need to be taken at the earliest date possible. Other improvement possibilities will also need to be investigated.

6.4.4.15 Future VOR requirements and spectrum availability: It is projected that there will be very few new VOR requirements. The new requirements will include some service upgrades (i.e., an increasing of service volumes). There may not be sufficient spectrum to satisfy new VOR requirements, especially for implementation in high traffic density areas. One system improvement would be to for users to have 50 kHz aircraft receivers (see Sections 6.4.4.9 and 6.4.4.14.3).

6.4.4.16 Future LAAS requirements and spectrum availability: The present LAAS implementation plan (1999 FAA Requirements, Appendix B, LAAS Installation Locations, Revision 1, 2/8/2002) projects an implementation of 161 systems. The first system implementation is projected for FY-2004. Spectrum engineering carried out to date has identified sufficient spectrum resources above 112 MHz to satisfy these requirements, based on the following assumptions: (1) only one transmitter at one site, using two time slots of the eight time slots available on a single 25 kHz frequency channel, would be required at each airport; and (2) a service altitude and distance of 20,000 feet and 23 NM, respectively. If a larger coverage area, or additional transmitters and/or additional time slots would be needed to satisfy the navigation requirements for any of the airports analyzed, then the results of the analysis may not be valid.

6.4.4.17 Future SCAT-1 requirements and spectrum availability: No new installations of this non-Federal Special (i.e., non-public use only) Category I precision approach GPS-aided system are expected.

6.4.4.18 Future VDL-4 requirements and spectrum availability: As a result of the ADS-B link decision process, the FAA has decided not to implement VDL-4 in the NAS (See Section 6.4.4.10 above)

6.4.4.19 Future TLS requirements and spectrum availability: This is a Special Use Only (i.e., non-public use only) non-Federal system, that allows one aircraft at a time to conduct precision approach operations. It will require frequency assignments on both ILS Localizer and Glideslope frequency channels, as well as use of the 1030/1090 MHz Secondary Surveillance Radar (SSR) beacon band. Based upon inputs from a

Congressionally mandated program on TLS, it is projected that only about 15 TLS systems may be implemented in the United States. Frequency engineering has been completed on several test bed TLS systems to date.

6.4.5 328.6-335.4 MHz ILS Glideslope band

6.4.5.1 The ILS Glideslope operations are implemented in the 328.6-335.4 MHz ARNS band. There are currently 1020 FAA and 136 non-FAA ILS Glideslope frequency assignments in this band.

6.4.5.2 Future ILS Glideslope requirements and spectrum availability: One Glideslope will be required for each Localizer to complete an ILS installation. Except for the lack of potential interference from FM broadcast stations, a similar frequency congestion problem exists for ILS Glideslopes as for Localizers. It is assumed that if an ILS Localizer can be implemented, it will be possible to implement an associated Glideslope as well.

6.4.6 960-1215 MHz DME/TACAN band

6.4.6.1 Frequency congestion: There is severe frequency assignment congestion in the 960-1215 MHz band, as a consequence of the many DME and TACAN operations in this band, and two SSR channels centered at 1030 MHz and 1090 MHz (where 20 MHz and 11 MHz, respectively, are protected for these channels). (The use of the SSR system will be documented in the surveillance section of this report.) Currently, there are 709 FAA and 924 non-FAA DME frequency assignments, and 613 FAA and 48 non-FAA TACAN frequency assignments in the 960-1215 MHz band. As a result of the frequency congestion, it is very difficult to implement new DME/TACAN operations in this band. In addition, the new GPS L5 civil signal and the UAT are planned to operate in this band.

6.4.6.2 GPS L5 issue: A new worldwide frequency allocation was obtained at the 2000 World Radiocommunication Conference for the new GPS civil aviation signal, called L5. L5 will be included in the new generation of the GPS, in addition to the present L1 civil signal, with Initial Operational Capability (IOC) scheduled for 2013. L5 is planned to operate in the TACAN/DME band at a center frequency of 1176.45 MHz (it should be noted that L1 transmits at a 1 MHz bit rate, while the new L5 signal would transmit at a 10 MHz bit rate). Ground DME transponder and Joint Tactical Information Distribution System/Multifunctional Information Distribution System (JTIDS/MIDS) transmissions have the potential to interfere with L5 signal reception on aircraft. Therefore, depending upon the density of DME implementation within a geographic area, DME frequency assignments on the center frequency and up to 9 MHz on either side of 1176.45 MHz may need to be changed to different DME frequency assignments. A plan will need to be developed for the DME frequency re-assignment actions.

6.4.6.2.1 In order to make the GPS L5 civil signal more tolerant of interference, including allowing it to operate in areas with a low implementation density of DMEs without requiring any DME frequency assignment changes, the L5 signal has been planned to be 6 dB higher in power than the present L1 GPS signal. However, current presentations by the GPS satellite contractor support levels only 1.4 dB above the present L1 signal (i.e., 4.6 dB weaker than planned). This will impact the ability of the signal to coexist in its intended environment. The DOD GPS Joint Program Office representatives continue to negotiate with the satellite contractor to achieve the full agreed power; however, no final decision has been made. In the view of the FAA, the 6 dB increase in L5 signal level (over L1) is critical for the future success of GPS as a principal civil navigation system.

6.4.6.3 UAT operation on DME ramp tester channel: The UAT, an Automatic Dependent Surveillance-Broadcast (ADS-B) alternative, operates on a center frequency of 978 MHz, with a 1 MHz bandwidth. This is a DME and TACAN ramp test frequency in the United States (a survey has revealed that there are only a few (7) operational DMEs and TACANs in the world on 978 MHz). Studies and tests have been conducted that indicate that there will be no mutual interference between ramp testers and UAT on this channel under the level of UAT operations assumed in the studies and testing. From an integrity standpoint, no potential for interference has surfaced (each of the systems (UAT and DME) have significantly different pulse/data coding techniques). ICAO has agreed to initiate the development of SARPs for UAT.

6.4.6.4 Directional DME antenna problem: Because of the high degree of frequency assignment congestion, the use of directional DME antennas has been introduced. The directivity of the antennas allow for a DME service to be implemented, that otherwise would not be allowed (the broader DME service coverage provided with a conventional omni-directional coverage antenna would cause interference to adjacent DME frequency assignments already implemented). However, the limited coverage provided by the directional antennas may lead to operational usage problems, stemming from, for example, the limited ATC routing that can be supported (and a loss of flexibility in changing ATC routing). In addition, users sometimes assume that the DME coverage is omni-directional, when it is not, thereby resulting in user complaints.

6.4.6.5 Narrow band antennas on older TACANs: Older TACAN antennas are either high band or low band in the frequency range that they can support. Thus, flexibility is limited with these systems with regard to changing frequencies, which may be necessary to implement new systems.

6.4.6.6 Department of Transportation(DOT)/DOD Memorandum of Understanding: DOD JTIDS/MIDS operations are allowed in the 960-1215 MHz band. An MOU is being developed between DOT and DOD that will allow greater technical and operational compatibility between civil aviation systems (e.g., DME, UAT, and L5) and JTIDS/MIDS. This MOU, among other things, will require JTIDS/MIDS to have the capability to inhibit transmissions on select frequencies in the 960-1215 MHz band, in order to protect future civil systems planned to operate below 1030 MHz.

6.4.6.7 Future DME requirements and spectrum availability: The known new DME requirements (i.e., new installations requiring the engineering of new frequency assignments) are presented below in Figure 6.3.

Figure 6.3 Future DME New System Requirements

FY	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
OEP[1]	2	3	3	3	1	3		
AND[2]	22	22	22	22	22	22	22	23
AND	26							

(Related to Congressionally mandated ILS installations for FY-2001/2002; eight have been engineered to date.)

Notes: 1. Engineering for these DMEs associated with OEP ILS installations have been completed.
2. Engineering for these DMEs associated with Control Flight Into Terrain program requirements, as developed by the Civil Aviation Safety Team (CAST), have been completed.

6.4.6.7.1 Except for 18 Congressionally mandated installations, the frequency engineering has been completed for all the known DME requirements (see Figure 6.3). The DME frequency congestion problem impacts the implementation of ILSs, since a DME is associated with many of these systems. While directional DME antennas may cause some problems (see above), their use is one means of alleviating the ILS related problem. This alternative has not been used significantly to date.

6.4.6.8 Future TACAN requirements and spectrum availability: It is projected that there will be very few new TACAN requirements. Sufficient spectrum should be available to satisfy any new TACAN requirements.

6.4.6.9 Future UAT requirements and spectrum availability: As highlighted above, no interference is anticipated from the operation of the UAT on the single channel (centered on 978 MHz) for which it is designed to operate with many aircraft. Unless a new channel is required, which has not been postulated, there is no foreseen future requirement problem.

6.4.7 1559-1610 MHz GPS/WAAS band

6.4.7.1 The 1559-1610 MHz band will need to be protected in the future for the exclusive use of present and evolving future Radio Navigation Satellite Services. The GPS operates in this band; the civil aviation signal (L1) is transmitted in this band from satellites on a center frequency of 1575.42 MHz. While the pseudo random noise (PRN) coded signal is only transmitted at a 1 MHz bit rate, the protection of a sizable bandwidth is required to ensure adequate reception of the signal information. The WAAS satellites will also transmit on the L1 signal format on the same center frequency. It should be noted that that Russian GLONASS satellite navigation system also operates in the 1559-1610 MHz band.

6.4.7.2 Future compatibility between GPS and the proposed European Galileo satellite navigation system: Europe is designing a new satellite navigation system called Galileo, that would operate in the 1559-1610 MHz band. A binary offset code (BOC) transmission format, which would interleave with the GPS signals in the same band, has been proposed. This evolving design will have to be reviewed carefully to ensure that there will be no interference to GPS.

6.4.7.3 Future GPS requirements and spectrum availability: No future spectrum requirement problem is foreseen regarding GPS (L1 civil signal), since it is a worldwide, non-saturating system. Thus, it does not require any further frequency assignments. Likewise, the WAAS satellites will operate on the same L1 frequency assignment as GPS, and, therefore, no future requirement issue is foreseen. Ground-based pseudolites, also transmitting on the L1 frequency, may be a system component in GPS-aided approach and landing systems.

6.4.8 5000-5150 MHz band

6.4.8.1 Operational civilian MLS systems in the United States: There are still 10 operational civil MLS systems in the NAS, which operate in the 5030-5091 MHz portion of this band. These systems must still be protected for operational usage. However, there are continuing pressures from industry to gain some degree of usage of the band used by these MLSs. Therefore, the FAA must continue to protect this band from encroachment.

6.4.8.2 FAA still supports DOD MLS requirements: In addition to the civil MLS systems operating in the band, there are presently 29 DOD Mobile MLSs (MMLS) operating in this band that the FAA needs to support, and additional DOD MMLSs are expected to be implemented. This is another reason why the FAA must continue to protect this band.

6.4.8.3 Potential requirement for new airport wireless local area network in 5000-5150 MHz band: In addition to protecting the 5030-5091 MHz portion of the band for MLS operations, there is a potential new requirement for an airport wireless local area network, called Airport Network and Location Equipment (ANLE), which would operate in the broader 5091-5150 MHz band, and would include both aircraft-ground and ground-ground communication links. The objectives of ANLE would be to provide more information to the pilot/cockpit and reduce runway incursions. The International Air Transport Association (IATA) has developed a system concept, called Airport Vehicle Position System (AVPS), which is aimed at a system implementation of the ANLE functions, and would operate within the 5000-5150 MHz band. Therefore, the entire 5000-5150 MHz band needs to be protected for future ARNS usage.

6.4.8.4 Future MLS requirements and spectrum availability: While the present MLS operational systems must be protected, there are presently no plans for the implementation of new MLS systems in the NAS.

6.4.9 Ultra wideband issue: A new initiative, approved by the FCC despite the strong concerns expressed by the Department of Transportation, the Department of Defense, and the National Aeronautics and Space Administration, allows very wideband low power transmissions to be implemented throughout the frequency spectrum below 960 MHz and above 1.9 GHz as FCC Part 15 devices. In addition to the potential for interference to civil navigation systems operating within frequency bands used by these devices, out of band emissions from these devices have the potential to interfere with such systems as GPS L5. The FAA will need to carefully follow the development of these systems to ensure that it will not cause RFI to the civil aviation navigation systems operating in all the ARNS bands.

6.4.10 Loran C not in properly protected band: Loran C operates within the frequency range of 90-110 kHz, in a band not allocated to the ARNS. The FAA is considering the use of Loran C in a future NAS navigation system mix. AF will have to work carefully within the FAA to ensure that any evolving future mix of civil aviation navigation systems, which may include Loran C, will be afforded adequate protection from RFI.

6.4.11 Associated requirements: It should be noted that a number of ARNS facilities also require radio frequency spectrum in addition to that which is required to communicate with the aircraft. For example, the WAAS requires fixed satellite service radio links for the ground-to-satellite links. The LAAS and TLS may also require ground-to-ground radio links to satisfy the stringent system interconnection requirements. At the present time, the satisfaction of these requirements has not posed a problem with respect to satisfying future navigation service requirements.

6.5 Summary and conclusions

6.5.1 A total of 17 present, future, and potential future navigation systems were examined in this report (see Section 6.4.1.1). A number of spectrum management issues that do or may have an impact on the satisfaction of future navigation system spectrum requirements were addressed. Finally, the evolving navigation spectrum requirements to the year 2010, to the extent they are known, were highlighted, along with the results of spectrum engineering work aimed at satisfying these requirements.

6.5.2 It will be very difficult to satisfy a substantial number of new requirements for the ILS, VOR, and DME systems in, in particular, the higher traffic density areas of the NAS, due to existing frequency assignment congestion. Locations now exist where it may not be possible to implement new ILS installations. If the historical requirement for about 25 new ILS (with DME) systems each year continues as expected, the frequency requirements for them will not be able to be satisfied at many locations.

6.5.3 Thus, timely action needs to be taken if the life of the ILS system is to be extended. In particular, the possible improvement alternatives need to be identified and investigated. One improvement to consider would be to require the user community to equip with 50 kHz channel receivers, possibly adhering to the new ICAO immunity standards.

6.5.4 A new worldwide frequency allocation was obtained for the new GPS L5 civil signal at the 2000 World Radiocommunication Conference. Since it will operate in the DME frequency band, a plan will need to be developed to re-assign some DMEs to other frequency assignments. An issue still to be resolved with the DOD is to obtain the needed power level for the new L5 civil signal, which, in the view of the FAA, is critical for the future success of GPS as a principal civil navigation system.

6.5.5 Other issues highlighted in this report include: (1) Loran C is being considered to be a part of a future navigation system mix, but does not operate in an ARNS band; (2) Ultra Wideband devices, approved by the FCC, are allowed to transmit low power, wide band signals in spectrum below 960 MHz and above 1.9 GHz, as FCC Part 15 devices; and (3) the transmission format of the new European satellite navigation system, Galileo, would interleave with the GPS signals in the 1559-1610 MHz band. Based on information to date, no insurmountable problems were foreseen in satisfying the known future frequency assignment requirements for the other navigation systems addressed in this report.

6.5.6 In the next year, new spectrum requirements for navigation systems to the year 2010 will be evaluated, and the navigation system spectrum management issues will be re-evaluated and modified as necessary, to reflect an up-to-date judgment of whether there will be sufficient spectrum availability to satisfy the navigation system requirements to the year 2010.